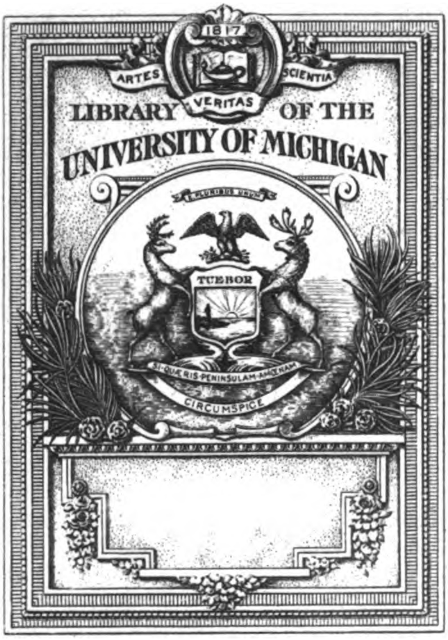
Section on Surgery

American Medical Association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TRANSACTIONS OF THE

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SECTION ON

Surgery and Anatomy

of the
American Medical Association
at the Fifty-ninth Annual
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INTRODUCTORY REMARKS BY THE CHAIRMAN BEFORE THE SECTION ON SURGERY AND ANATOMY, CHICAGO, 1908.

RUDOLPH MATAS, M.D.

NEW ORLEANS.

Distinguished Guests and Fellow Members: I feel, as your presiding officer, that I would be remiss in the discharge of my duty and grievously at fault with my own sentiments, if I failed to notice that this day is made sadly notable by the absence of one who for more than a quarter of a century was a Titan in our midst and whose voice, now stilled forever, thrilled and swayed our assemblies with the fervor of his eloquence, the magnitude of his accomplishments, the stimulus of his example and the vast power of his exhaustless energy—Nicholas Senn.

Vir præclarus et ornatus—Senn, the incomparable teacher, the peerless clinician, the scrutinizing pathologist, the perennial investigator, the faithful historian and charming raconteur; the world traveler, the philosopher, soldier, patriot and organizer; Senn, the philanthropist, the citizen of Chicago and of the world; Senn, one of the greatest masters of our art—will remain an imperishable name in the great pantheon of American surgery. His passing out of this community, of which he was a *magna pars,* must be felt like the

extinction of some great elemental intellectual force, as serene and unfailing and strengthening as the great natural forces that freshen and invigorate the earth.

In the shades of this great and hospitable metropolis, for so many years the center of his tireless activity; in the great city which he enriched by the products of his puissant intellect and generous bounty; in the heart of this great Northwest—so prolific in extraordinary men; here, in this region of vast potentialities, and following in the footsteps of his eminent predecessor and friend, Christian Fenger—he sowed and assiduously cultivated the vigorous seed of Teutonic genius and made it yield rich fruit in the cult of surgical philosophy and surgical art. Again, in the councils of this Association, which he strengthened by his wisdom and example; in the gatherings of this, his special section, where he stood as a high priest at the shrine of science; and throughout the American continent and wherever the science and art of surgery are taught and practiced and the language of medicine is spoken, the name of Nicholas Senn will always be mentioned with reverence, honor and affection.

His life work, his deeds and marvelous achievements have become a part of the history of surgery. His unparalleled labors have been told only too recently by more eloquent and gifted panegyrists to justify repetition on this occasion. As one who enjoyed the privilege of his personal friendship and encouragement in the earlier days of his professional life, and in the name of this great gathering of representative American surgeons, his associates and fellow workers, successors and friends, now assembled to prosecute and continue the great work with which his life was most closely identified—I join the medical profession and people of this great city, especially those within the immediate circle of his life, who mourn his loss with the greatest poign-

ancy, and condole with them in profound sympathy at a common bereavement.

* * *

As the needle on the dial points to the hour when the "Clans must gather to the trysting place," we are reminded that the Section of Surgery and Anatomy will now assemble for the forty-seventh time since June 7, 1860, when it was created a separate arm of our national body. As the chariot of time has rolled by, each annual session has left its impress on the history of American surgery, an imprint which has yearly become wider, deeper and more indelible, as the parent organization has advanced in maturity, strength and prosperity.

The labors of our predecessors have not only contributed to our individual betterment as members of this guild, but they have added to the dignity and luster of surgery by their magnificent accomplishments. With this great heritage and its traditions, a measure of accountability for the safeguarding of the trust has also been handed to us, which adds to the grave responsibilities of the hour. As I stand before this great gathering of distinguished fellow-workers, privileged by your grace and good will to give the signal which is to inaugurate the forty-seventh session and launch it into history, I feel profoundly conscious of my own shortcomings and unworthiness, yet deeply grateful that I should be vouchsafed the privilege of gazing on the inspiring and magnificent panorama offered by the ever expanding conquests of American surgery, from this lofty height.

As I survey the field before me and read the past, the present and the future, in the faces of the stalwart men who represent the diverse generations of productive workers here assembled, including those who have

accomplished, those now accomplishing, and those who are still to accomplish great deeds, and who are to exalt our traditions, I feel assured that one year more of fruitful endeavor and achievement will be added to the emblazoned and imperishable chronicles of our organization by the proceedings of the surgical section, which I now have the honor to open.

LOCAL APPLICATIONS IN SURGERY.

JAMES E. MOORE, M.D.
Professor of Surgery in the University of Minnesota.
MINNEAPOLIS.

A skeptic is one who refuses to accept any man's *ipse dixit.* He refuses to believe dogmas simply because others believe them and to do things because others have done them. He demands proof. Long live the skeptic! The object of this brief paper is to encourage skepticism in local therapeutics, to discourage the use of local applications without positive proof of their efficacy, and to call attention to the ease and certainty with which the desired information may be obtained.

Empiricism is a term used in a very loose sense and is capable of many definitions. The most commonly accepted definition is "practice based on inadequate knowledge which has been derived from a narrow range of observation without any warrant for its exactitude." An ancient sect of Greek physicians who maintained that experience is the foundation of the science of medicine called themselves empirics in contradistinction to those who relied on theory. Our effort at the present time is to base our practice on exact scientific knowledge, but it is not given to us to know all things, and until medicine has become an exact science empiricism must prevail. The greatest need of our profession is to get away from irrational empiricism and, when we must base our practice on experience for want of a scientific foundation, to insist that our experience shall bear the test of comparison.

Surgeons are prone to claim that their specialty is an exact science, but there is no place where there is more of irrational empiricism and less of science than in our use of local applications. We have inherited the habit of making applications to wounds and inflamed parts from our forefathers whose practice was almost wholly empiric in its worst sense. It is true that we have made advances in the use of local applications because the filthy poultices so popular with our forefathers have given place to others less objectionable if equally inefficient. Local applications always have been and doubtless always will be popular with the laity, and there is a decided tendency in the profession to make these applications and to attribute to them the improvement due to Nature's efforts. It is high time that we abandon this *post hoc* reasoning in surgery and recognize the fact that the natural tendency is for a wound to heal and for inflammation to disappear through the unaided efforts of Nature.

The mere fact that a swelling disappears after a local application has been made is no proof that the application had aught to do with the disappearance. Many different preparations have had each its season of popularity only to give way to others. A very decided color and a particularly offensive odor have usually been the best recommendations for popular favor. Icthyol, for example, one of the recent favorites, is a filthy, vile-smelling stuff made from fish dead and rotton for several thousand years. Shades of Esculapius! The fact that one favorite is so soon displaced by another is proof of its inefficiency. Our allegiance to opium and its preparations has never wavered since its discovery, because its power as an anodyne can be demonstrated at any time, but its popularity as a local application is on the wane because we have learned that it relieves pain only after it is absorbed and that absorption takes place much more quickly when it is taken into the stom-

ach or injected underneath the skin. In other words, its effect is general and not local, no matter how administered. This being true, why, for example, should we make a local application of opium in the form of a suppository after an operation for hemorrhoids when we can secure a more comfortable and certain result from a hypodermic of morphia? It seems strange that we should have used local applications so extensively without proof of their value when the proof is so near at hand. It is a comparatively easy matter to make local applications in a series of cases and to compare them with another series of like cases in which no applications have been made. When put to this test the vast majority of local applications are found to be absolutely valueless. The present trend of therapeutics in general is not toward nihilism, as some would have us believe, but it is toward the elimination of drugs and applications the usefulness of which can not be demonstrated either by scientific investigation or rational empiricism. When our profession has followed this tendency to final analysis, and when it has learned to insist on as exact and complete a diagnosis as is possible in every case, no matter how insignificant it may seem, there will be much less quackery. We are very largely responsible for the many medical fakes because we have not done our work as well as we should. We have been too ready to prescribe without proper diagnosis and to employ useless remedies just as the quacks do.

It is because we have failed to give Nature due credit for her healing powers that such an absurd cult as Eddyism has taken such hold on the people. When a faith healer sits around and does nothing but think, while Nature is making a cure, and then attributes the cure to his masterly inactivity, he is only following our example when we paint a swollen joint with iodin and claim that the resolution due to Nature's efforts is due to the fact that we have changed the color of the skin. It is true that only a few years ago we painted all man-

ner of swellings with iodin and watched the swelling disappear with great satisfaction, feeling that we had undoubtedly assisted Nature with our decorations, but it is equally true that we seldom make this application now and that the swelling disappears just as promptly and with less discomfort to the patient.

Liniments and blisters are still very popular with veterinary surgeons, but they have fortunately fallen into disrepute with us. Liniments have their uses, but their curative effect has not been demonstrated. They often relieve pain, and when "well rubbed in" the massage does good, and the patient gets the benefit of suggestion. Their greatest advantage is, however, that they give the patient a feeling that something is being done for him and keep him and his sympathizing friends busy, thus preventing them from doing something else which might interfere with the cure Nature is bringing about, rather a humiliating admission when we recall the former popularity of liniments with the profession.

It is rarely, indeed, that the one-time popular blister does more than add to the discomfort of the patient.

It is only a few years since every surgeon felt it his duty to cover his wounds with some dusting powder, but we have learned that wounds heal just as quickly without the powder, and it is getting to be well understood that every unnecessary application to a wound is meddling with Nature's process and that meddlesome surgery is bad surgery. The fact that iodoform was the most popular dusting powder was doubtless due to its vile odor.

Medicated dressings, so popular at the beginning of the Listerian era, have practically gone out of date because experience has proved that they are not only useless but sometimes harmful. Iodoform gauze is about the only one left and it is on its last legs. The results obtained by the best surgeons demonstrate that the only application necessary for a fresh wound is dry sterile

gauze to absorb any possible discharge and a covering of sterile absorbent cotton to prevent contamination. The value of these simple dressings is doubtless overestimated because brilliant results have been obtained in superficial burns without dressings by simply protecting the parts from the bed covering by means of a cradle, and it is well known that wounds about the face heal promptly without dressings. On a tightly-closed wound the real function of the simple dressings previously mentioned is to add to the comfort of the patient by protecting the parts from the clothing and to prevent contamination from meddlesome fingers. On an open wound they undoubtedly have a value in preventing atmospheric infection.

It is no longer necessary to denounce the use of strong chemical solutions on a fresh wound, because they have been so generally abandoned, but they are still being used in infected wounds to an unwarranted extent. Frequent irrigations of a suppurating wound will not stop suppuration and they will delay the granulating process. I have repeatedly treated two infected wounds on the same person, one with irrigations of bichlorid solution 1 to 2,000, and the other without, and have found that the wound which was not irrigated invariably did the better. Irrigation with normal salt solution is better than with sterile water because it is more grateful to the patient, just as an application of salt solution to the Schneiderian membrane is more grateful than one of pure water. Irrigation with the salt solution should only be resorted to when it is the best mechanical means of removing retained discharges. Anything beyond this is meddling. An open wound and gentle pressure are much better than any irrigation.

The application of 95 per cent. carbolic acid, as first recommended by Powell, is the most important advance made in the matter of local applications for many years. A very virulent infection can often be cut short by the

application of this drug, which destroys all bacteria, and when followed within two minutes by alcohol there is no danger of absorption and the amount of tissue destroyed is very small, and instead of causing pain it acts as a local anodyne. Before this discovery the hot iron was our only means of securing like results and this caused great pain and destroyed too much tissue.

Heat and cold, either moist or dry, are the most popular local applications at present and their popularity leads to their abuse. Our only positive knowledge concerning them is that they do relieve pain. Their curative value is still a moot point. When one physician is a strenuous advocate of cold applications for a certain malady and another is equally strenuous in his advocacy of the application of heat for the same malady, the chances are that both are indulging in some *post hoc* reasoning and that the patient would be cured of his malady by Nature just as quickly had they relieved his pain in some other way. In an inflammation of the skin or superficial parts the application of heat and cold must have some effect from their action on the blood vessels and nerves, but whether for good or ill is not so certain, and without definite knowledge their application beyond the point of relieving pain is unwarranted because they may do harm instead of good. The application of heat or cold for a deep-seated disease like appendicitis, so far as any curative effect is concerned, seems to me the height of folly. Their advocates believe that their efficacy depends on the lowering or raising of the temperature of the diseased part, and it is a physical impossibility to change the temperature of the appendix by any external application because of its remoteness and of the circulation of many currents of blood of a fixed temperature between the skin and the diseased organ. We must not forget that at least 80 per cent. of these cases will recover if we let them alone. The worst feature of this subject is that in a great many

cases the patient has lost his life because his doctor had such faith in local applications that he continued to use them until it was too late for a life-saving operation. This remark is equally true of a host of other applications. We have all seen cases of cancer treated by local applications until all hope of cure by operation was gone. It is only too true that in many cases cancer is not cured by operation, but patients who are cured are operated on early, and nothing is so likely to cause delay as misplaced faith in local applications.

It is very trying to a surgeon to be called to see a patient and find the affected part has been plastered all over with "antiseptic mud" (save the mark) or some other equally objectionable and useless substance.

In the popular treatment of a crushed hand irrational empiricism runs rampant. One person will apply moist heat, thereby encouraging the ravages of bacteria, the one thing to be feared most, while another will apply cold until what little vitality was left in the crushed part is destroyed and gangrene results. In this case the modern surgeon, after thoroughly cleansing the part, applies sterile gauze and absorbent cotton for protection and comfort and allows Nature to choose her own temperature.

The abuses of heat and cold are too numerous to mention, but one or two examples may not be amiss. One of the most common abuses of heat is in the treatment of phlegmon of the hand. Every surgeon has cases brought to him after the patient has had poultices applied until the tendons are destroyed when early judicious incisions would have saved the hand and much suffering. The local application of heat in these cases is the most grateful possible and it should be used for the comfort it gives the patient but without any expectation that it will bring about a cure. When used in this way it should not interfere with rational surgical treatment and it accomplishes good without harm.

Recently a man came to me, stating that his sister had been suffering for six days from an acute attack of appendicitis and that her side was turning purple. I supposed that it was an abscess case with the "green groin" of old writers, but found on her arrival at the hospital that a thin rubber bag filled with cracked ice had been so faithfully applied for six days that the abdominal wall was frozen down to the superficial fascia. About this same time I read of an instance in which a French physician met with this same misfortune and his patient secured a verdict against him for malpractice.

DISCUSSION.

Dr. H. A. Royster, Raleigh, N. C., said that in our eagerness nowadays to operate, we have been neglecting some very important surgical principles. A surgeon's reputation is often made, or marred, by the so-called minor things. The paper under discussion deals chiefly with the abuses of local applications and not their uses. Dr. Moore has reached the other extreme, but he has set a good pace. His remarks on the abuse of local applications apply with equal force to medical and surgical conditions. Surgery is more exact than medicine, but only in the operative field. We may not be any more sure of cause and effect than the internist. His befuddled statement that the swelling disappears after a local application has been made, is no proof that the application has aught to do with the disappearance of the swelling. The same might also apply to bandaging, rest, lapse of time, etc. Montaigne said, in regard to the ailment and its cure, whether it came about from the lapse of a sufficient number of days, the remedies employed, the nature of the disease or his grandmother's prayers, one could hardly say. The same is true of local applications, because there is always that tremendous factor, the forces of nature.

Dr. Royster would not like to give up using ichthyol, which Dr. Moore so vehemently condemns, even though he felt that the massage and pressure accompanying it win half the battle. He also confessed to the use of the lead and opium wash in epididymitis. He still went so far as to blister a chronically inflamed kneejoint, knowing that the patient would be rendered more uncomfortable thereby, and, perhaps, doing it for that reason in order to relieve the monotony. He felt sure, also, that there is a place in surgical therapeutics for ointments containing the proper medication; particularly for oily dressings so commonly employed nowadays—balsam of Peru and

castor oil, and also the alcoholic dressings. When a local application does no harm, and there is a rational basis for its use, no one should condemn its employment. When it does harm, it should be rejected. When symptoms are obscured thereby, or proper treatment is postponed, one is guilty of malpractice if he continues the use of a local application.

One weak point in Dr. Moore's armor is the fact that he apparently disapproves of the mental effect procured by the use of liniments. Theses things are very useful when they are harmless. Dr. Royster desired to emphasize the harm done by counter irritation to the abdomen in cases that later come to operation. The skin may be frozen by ice, reddened by mustard, and blistered by cantharides. Much damage is done by such local applications, in addition to the delay caused by their use.

DR. HOWELL, Columbus, Ohio, said that if you place a constricting band around the leg above an inflamed kneejoint and produce a hyperemia below the band, it is exactly the physiologic action produced by heat and cold. It is simply hyperemia.

In case of phlegmon, Dr. Howell would go further than Dr. Moore, and use, in addition to his treatment of gauze and a soft bandage, a splint. Infection travels by way of the lymphatics toward the body by means of muscular action, and if there was ever good done by a citizen of this city, it was when Ochsner so graphically described the course of infection through the lymphatics by muscular action. This is a befuddled point in surgery to-day. In phlegmons of the hand or of any other part of the body, not only should you apply a gauze dressing, but rest of the part should be provided for.

From an experience that covers the average surgeon's life, Dr. Howell said that alcoholic solutions, medicated or not, kept moist on an inflamed part at rest, will produce better results than when the part is at rest and dry. The same is true of counter irritation used by the old family doctor. It is simply a matter of Bier's hyperemia put into another form.

DR. A. J. OCHSNER, Chicago, believes that, while you are doing useless things, you must be certain that they are harmless. Most applications keep the applier from doing worse things. He believed that the good of rest is enhanced by many of these applications, and that in so far as these applications enhance the value of rest, they are of advantage to the patient. Close observers have found a very large amount of comfort when they have had personal experience with many of these application, so that there is something of good in them for the patient. Dr. Ochsner had peritonitis many years ago, and remembers well the great comfort received from a large flax-seed poultice. When this poultice was removed, the discomfort returned; when the poultice was reapplied, the discomfort disappeared. It does not matter whether there is a scientific explanation; whether it is Bier's hyperemia or

whether it is not. So long as the discomfort disappears when a thing is done, continue to do it. There is benefit in the use of many of these things. He believes that it is largely the benefit of rest or hyperemia.

DR. T. J. CONLEY, Chicago, would be very loath to give up iodoform, salicylic acid and boric acid without some good reason. They do not destroy the streptococcus, but they do destroy the staphylococcus, and in that way they do a great deal of good.

DR. JOHN B. MURPHY, Chicago, said that we should learn to let these wounds alone, to keep our hands off. Let them stay clean, and they will get well. The irritating solutions that have been used, the handling that has been done, the rubbing and scrubbing that is outrageously done, the milking of an abscess, are abuses that the profession should not countenance. The temporary relief which is received from the applications of heat or cold on non-abridged surfaces is very much to be commended. What that application will be is a matter for us to select. But the wet dressing, the pus poultice in the management of open wounds, is a very great detriment to the healing process. No more striking example can be cited than a pure infection of the pelvis of gonorrheal origin, where a pus tube is ruptured in its removal, and you have the pus poured out in the lower portion of the pelvis. If you put in a drainage tube, and it is kept in for a week or ten or fifteen days, it will be two or three weeks before the case will heal up and before the discharge will cease. Why? If you take one of these cases, the enormous percentage of which are aseptic, notwithstanding the pus, close that abdomen, the patient is out of bed, and well in a week or ten days. That is purely evidence of mechanic irritation and retarding of healing process. All irritation of open surfaces should be abandoned. Wounds will heal more rapidly without it.

DR. ROBERT F. WEIR, New York, said that to keep wounds at rest and clean is the best treatment we can follow. But when you come to painful swellings, such as a boil, put on a little heat and it feels better. There is no question about that; but let us know what we are doing. The moisture used allows stretching of the dry skin. Therefore, he believes in a little moisture. There is a point about heat that is worth dwelling on. It does not do any good to the inflammation or to the septic process, but it stops tingling and aching of the nerves. Therefore, Dr. Weir is willing to adhere to a little moisture, hot moisture, on a painful swelling. Otherwise let it alone.

DR. ARTHUR DEAN BEVAN, Chicago, said that in an infected wound of the hand, he believes that the best dressing is the continuous moist antiseptic dressing, very mildly so, either boric acid or acetate of aluminum in a very weak solution; and he believes that it is scientific. The bacteria are rendered

less noxious; their growth is inhibited in the dressing, and the drainage is better. The wound secretion flows into the moist dressing, and it is picked up better by it than by the dry dressing, which is hard and uncomfortable. The wet dressing certainly is more comfortable to the patient, and on that account, he is very much in favor of the moist antiseptic dressing in painful swellings.

Dr. Bevan is coming to the use of ointments a good deal. He likes zinc oxid best where the dry, inflexible gauze dressing is uncomfortable to the patient. The old-fashioned flaxseed poultice may be of much value. Why can not such a poultice, when made antiseptic by boiling, be a good dressing and carry no danger to the patient, especially if it gives comfort?

Dr. Jabez N. Jackson, Kansas City, Mo., said that the action of heat had been discussed simply from the standpoint of hyperemia, the stimulating action of heat on the capillaries. As a matter of fact, he is firmly convinced that the effect of moist heat does not in any sense depend on its effect on the vascular system. Heat has a distinctive effect on the lymphatic system. What happens from the application of heat, either dry or moist, to the skin surface? Your hand is scalded with hot water, and a blister forms. The lymph has been drawn from its usual channels and carried into the skin, showing that the heat has a distinct effect on the lymph circulation. The effect of heat does not depend altogether on the degree of temperature, but on the length of exposure to a uniform temperature. If moist heat is kept up continuously for a time, it has the same effect as has a high temperature for a short time. The effect of heat is to produce outward drainage of the lymphatics; to stop the proximal flow of lymph. The effect of heat is on the lymphatics and not on the blood vessels.

Any agency which can stop the lymph circulation will localize infection. It does not matter what agent or material is used so long as you get the effect of the heat, get a lymph stasis, which will arrest the spread of the infection. In the case of the spreading infections, we add to the moist heat simple incisions and control the infection very rapidly. The application of moist heat in an ordinary contused wound is illogical because it causes lymph stasis and localizes the infection, whereas, if lymph flow is promoted, infection is prevented.

Dr. Charles Parker, Chicago, commended the wet dressing. Pus in a poultice is better than pus in a wound. The wet dressing should consist simply of ordinary sterile gauze wet with sterile water or salt solution. He did not believe in the necessity of antiseptics. On top of that is placed some impervious tissue. The wet dressing has several functions. One is the absorbing function. It does absorb and clean the wound. An ounce of good absorbent gauze will absorb four ounces of

water. When it is moistened, it will weigh about two ounces. It absorbs possibly better than the dry gauze. Dry gauze with plenty of pus will absorb rapidly, but a small quantity of pus will dry in the gauze and from that time on there is no more absorption.

The wet dressing acts as a mechanical diluter of the pus. Change it often. Our final reliance must be on the cells of the tissue. Save as many of these cells as you can. A dry or open dressing allows desiccation of living cells. Now, there are bacteria in the tissues, on the surface and in the dressings. Those in the dressing we do not care about. We can throw them away. Those on the surface are diluted, and a certain number of them go into the dressing. Those in the tissue, none of your antiseptics can reach because the antiseptics will kill the cells if used strong enough to kill germs. Phagocytosis will solve the problem for you. Alcohol and antiseptics of all kinds decrease phagocytosis. Save your antiseptics. Induce the lymph to flow into the wounds. Have some means of drainage. Above all, preserve, all the cells you can. Keep them warm. Put on a wet dressing, hot or cold; it will soon be at the temperature of the body.

Dr. J. E. Moore said he is simply pleading for the discarding of useless applications and the use of those whose value has been proved. He uses them every day because they make his patients feel better; but they do not cure anything. We must have the extremist. Every time a man speaks of something new he is called an extremist, but in time we reach the happy medium, and then the extremist shall not have been in vain. He does not disapprove of bandages. He has seen swellings disappear many times under the use of bandages. His paper was a plea for surgery without meddling. Meddling is always bad. He has not irrigated a healthy wound for ten years, and he is proud of it.

Moist and dry dressings have their place, but we have no time to work this out to-day. Dr. Weir wants heat and moisture on his boil. So. does Dr. Moore, but it will not cure the boil. Dr. Connelly believes in putting on things to keep the patient busy, and Dr. Moore declared that there is our danger point, because we have not the right to keep our patient busy. Such things bring the profession into disrepute and give the Eddyite a chance to get in his work.

HYPEREMIA.

J. F. BINNIE, M.D.
KANSAS CITY, MO.

When some noxious influence acts on a more or less limited area of the body, local resistance is manifested by the production of granulation tissue and of hyperemia. Under favorable circumstances the granulation tissue repairs defects resulting from the noxa or more or less completely encapsulates the irritating agent. Under less favorable circumstances the irritation being continuous, e. g., in tuberculous infection, granulomata are formed, these granulomata being evidence of defense. If the resisting power is sufficient the embryonic tissue overcomes the irritant and encloses it in fully developed scar tissue. Stimulation of the production of granulation tissue in and around a tuberculous focus seems to be the therapeutic action of injections of emulsions containing iodoform, bismuth, finely divided carbon, etc., and of sclerogenic injections.

The second method by which Nature resists a noxa is by hyperemia. When an irritant, e. g., the staphylococcus, gains access to the tissues the flow of blood to the part becomes increased, there is exudation of fluids and leucocytes from the vessels into the tissues. The blood serum contains antibodies or antitoxins which neutralize the chemical products of bacterial activity, bactericidal agents which attack the bacteria themselves; opsonins which prepare the bacteria for absorption and destruction by phagocytes or perhaps act as a sort of appetizer or cocktail to the phagocytes, and lastly there are the leucocytes which act as phagocytes

directly killing bacteria or as scavengers removing the débris of the fight. Thus while the granulation tissue acts a sort of passive rôle besieging the invading irritant, the hyperemia directly and actively combats it.

It was noticed long ago that valvular disease of the heart causing pulmonary congestion seems to prevent the development of pulmonary tuberculosis. Bier, struck by this observation, thought that by producing local hyperemia he could modify or cure tuberculous lesions in various parts of the body. He produced the necessary congestion by applying a rubber bandage proximal to the lesion—in a limb. Only sufficient constriction was used to produce a warm swelling. The constriction must never be severe enough to cause coldness, pain or even paresthesia. The results obtained in tuberculous lesions led Bier to extend the treatment to various other infective lesions in which the results have been most gratifying. Klapp, who is associated with Bier, thought that the same results might be more conveniently obtained by the use of cupping glasses of suitable shapes and sizes. It is with this last method that I have had most experience, and I have come to have much faith in it.

METHOD OF USE.

If pus is present it is evacuated through a comparatively small cut or puncture. The suction of the cupping glass will notably aid in the removal of the pus. A suitable cup which completely covers the lesion is applied. Suction is produced by means of a rubber bulb or a syringe. The suction must be strong enough to produce a red swelling of the part. If the swelling becomes blue the suction is too powerful. The same is true if pain or paresthesia is occasioned. The suction is kept up for five minutes, the cup is removed for three minutes, and reapplied for five minutes, etc. This alternation of five minutes of suction and three minutes

of rest is persisted in for about forty-five minutes daily. The patients quickly learn the correct degree of suction to apply and soon can carry out the treatment better than can the surgeon. The suction exerted brings an increased quantity of blood into the part and increases the exudation from the vessels; thus an unusual amount of the active protective material is brought into the place where it will do most good. The suction must be sufficiently strong to produce this condition but not strong enough to cause stasis of the blood in the part. There must be an increased inflow and only a slightly decreased outflow of blood in order that the maximum amount of the active fighting forces may be present during the whole period of suction. The periods of rest permit the escape of blood from the part, and thus when the suction is once more applied an entirely fresh supply of fighting material is obtained. Wright believes the escaping blood contains a vaccine which stimulates the production of antibodies throughout the economy.

In our student days we were taught that pain in an inflammatory lesion is due to mechanical tension or distention, i. e., it is due chiefly to the swelling. The injection of water into the skin produces a temporary pain —later anesthesia. The increased swelling occasioned by the proper production of hyperemia is followed by a notable and early decrease in pain. Pain in an inflammatory lesion seems to be due to irritation by toxins and especially to the high specific gravity of the inflammatory exudates. Hyperemia properly produced destroys or dilutes the toxins and dilutes the exudates. Every one knows the relief experienced when a tense inflammatory swelling is incised, i. e., when tension is relieved.

The tense swelling is due to an exudate of high specific gravity — the tension prevents the inflow of blood to the part and the escape of diluting serums from the vessels and when the tension is removed fresh blood flows into the part and relief is obtained.

C. Ritter[1] has proved that the freezing point of pus is always lower, sometimes very much lower, than that of blood or serum, which are alike. The pus of a cold abscess has a freezing point, that is, a concentration, almost identical with blood and serum. Inflammatory serum has a freezing point similar to that of pus. It is safe to say that the fluids of inflamed tissues are of higher concentration than those of normal. If these experiments and observations are true, then any treatment which tends to dilute the fluids of high specific gravity and bring them to a concentration equal to that of the blood and blood serum must relieve pain. Relief of pain is one of the marked features of the treatment by hyperemia.

In dispensary practice I have learned to trust to treatment by means of cupping glasses in those forms of cervical adenitis so common among the poor. If pus is present it is evacuated through a tenotome puncture and suction applied; if pus is not present cups are applied at once. Usually cure results in seven, eight or ten days and scar is notable from its absence. A most striking result was obtained in the following case:

Patient.—A farmer aged 37, suffered from a large bunch of glands of wood-like hardness situated behind the sterno-mastoid near the clavicle. This adenitis was secondary to boils on the back of the neck which had healed. There was intense pain preventing sleep.

Treatment.—Suction hyperemia was instituted and after two treatments the patient could sleep well and was comfortable. After four treatments all the periadenitis had disappeared, the glands decreased in size, were mobile and discreet. Complete recovery was prompt. Even after the first treatment the patient maintained that he felt distinct relief.

Another illustrative case was the following:

Patient.—W. J., aged 45, on Feb. 8, 1907, punctured his palm with a nail. In about two days there was much pain, etc., and poultices were applied.

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1. Arch. f. klin. Chir., 1902, lxviii, 437.

Treatment.—On February 12, the hand was much swollen both in the back and in the palm; great pain and tenderness were also present. Fingers were stiff. A small incision made in the palm (¾ in.) showed pus deeply seated; it was squeezed out. Suction hyperemia was applied by the patient about three times daily for 30 minutes at a time.

Result.—February 19: There was no pus, no pain. Fingers were mobile, though stiffer than normal. Swelling was almost gone. The pain was the first symptom to disappear.

I have seen a goodly number of buboes disappear promptly and with the minimum of trouble after the contents were evacuated through a puncture and hyperemia was produced by suitable cups. In the treatment of furuncles the cupping glass often acts like a charm and the abortion of boils is common.

I have thought it worth while to give a short description of the simplest possible treatment of some common and troublesome ailments because the simplicity and apparent futility of the treatment is calculated to keep many from employing it, but simple as the method is it has proved its worth not merely in the rather trivial ailments I have spoken of in this paper but in many serious lesions.

DISCUSSION.

Dr. M. G. Seelig, St. Louis, said that for three years he has made use of Bier's hyperemia both in dispensary and in private practice with good results. The patients, as a rule, have been spared not only the pain that goes with the infection, but the pain that goes with the dressing of all very painful wounds. In all these three years he has never used anything in the shape of a drain. In common with Dr. Binnie's experience he has limited himself almost exclusively to the cupping treatment of Bier, and based on that experience he has gradually grown more and more to believe that the pure mechanical evacuation action of the cup is of almost as much importance as the physiologic action. His results with the tourniquet have not been so good. In using the Bier cup you increase the pressure for a few minutes; with the tourniquet there is more or less danger of causing anemia rather than hyperemia.

The phase of Bier's hyperemia that always appeals most to him, and which for some reason is not emphasized in the literature, is the portion embraced in Bier's preface in his

original work, in which he emphasized the philosophic principles back of hyperemia. He considers that inflammation is a series of phenomena set up by Nature in an attempt to cure itself, and that it lies within the province of the doctor not to regard inflammation a witch or devil invading the human organism. This is important from a historical point of view, and if we go back a few years we find that Bier is merely upholding a doctrine which the celebrated John Hunter fought for.

DR. VICTOR J. BACCUS, Chicago, said that he did not believe in the treatment of Bier before he went to Berlin, although he had read everything that was written on the subject, and had tried it on half a dozen patients. After he got over there, he found that he did not know how to use the method and that that was why he had not been more successful. The ward cases soon convinced him of the value of the method. He saw cases of cellulitis of the hand, not limited to the fingers, but infections involving the hand and extending up to the elbow, so that any surgeon would have applied a hot dressing and opened the hand next day. The patient was put to bed and constriction was applied. The period of physiologic rest, according to Bier, had passed away, and in five or six days the constriction hyperemia caused the inflammation to decrease, and then the patient was encouraged to move the fingers. The object is to heal the part without mutilation, keeping the tendons functionating. If the inflammation is localized and there is danger of softening and necrosis, incisions are made in the skin, with or without local anesthesia, followed by cupping. Such hands heal in from two to three weeks and the patient is well. The bad results arising from the use of this method are due to faulty technic. With reference to the apparatus necessary, it is simply a rubber band, one or two cups and a hot air bottle, which any one can make for himself, the whole outfit costing not more than four or five dollars. Trust to the rubber band, use it according to instructions, and you will get results.

DR. D. N. EISENDRATH, Chicago, said he had tried this method of treatment by means of the constricting band and the cup at the Michael Reese and Cook County hospitals in hundreds of cases, and had come to certain conclusions. He has found that in the acute arthritis, the acute pyemic arthritis or gonorrheal arthritis, there is no better treatment than Bier's hyperemia by means of the constricting band placed proximally to the joint for two hours a day. It gives almost immediate relief from the pain. In tuberculous arthritis his results have been almost equally as good. It is remarkable how much can be saved in the way of operative treatment by a systematic and persevering application of this treatment. In regard to certain varieties of infections he would like to have Dr. Binnie's opinion. In cases of acute

streptococcus infections, those which travel rapidly up the arm or leg, he has found that the Bier treatment has but little effect, so that he has practically given it up and resorted to older methods of free incisions and hot applications and dressings. He has also found the method very useful in promoting union of fractured bones and also in preventing infection; for instance, in crushing injuries of the hand, when he has tried to save fingers, he often is in the habit of putting on constriction to prevent infection, and in many cases it has been of the greatest possible advantage. He thinks that the profession does not sufficiently appreciate the value of this treatment. If the treatment were applied only to certain cases and not to others, it would be more widely adopted because of the better results that would be obtained.

Dr. John B. Murphy, Chicago, said that there is nothing that he knows of that has come into surgery in the last ten years as a practical application that appears to him to have as much value, and, he is sorry to say, is practiced so little and is so frequently misused. He believes that its most important place is in the acute infections. Take, for instance, the crushing injuries of the hand, the infected wounds of the hand that produce such disastrous results, often leaving the hand a crippled member for the remaining portion of the patient's life. He believes that a very great majority of these cases can be aborted as simple infections of the finger or even the thumb with a properly applied constricting band or cup. Which should be used is a matter of convenience, but the aim should be to accomplish a definite purpose; to have a definite object in view. We have been talking about dispersing inflammation. Our forefathers poulticed hoping to scatter the infection. Every one now knows that that very infiltration is Nature's effort at holding in, circumscribing, retaining and overpowering the zone of infection. Anything that aids and strengthens that by increasing the edema, increasing the swelling, increasing the circumscribing power of the tissue in that part aids in the process of preventing the spreading of the infection. If you will bear in mind that the purpose of the Bier treatment is—never mind the theory—to hold and circumscribe that infection, and if you produce edema by means of constriction or cup, you will find that your patient is relieved of pain. It is better than a poultice, the coffer-damming is more complete than with a poultice, and you curtail the time that is consumed in repair. Dr. Murphy said that if he were in emergency practice to-day he would dispense with every dressing on a wound. After it has healed put on a cage of wire to prevent contact and use the Bier treatment to promote local resistance against infection that is present or may be imminent.

OBSERVATIONS ON THE THYROID AND THE PARATHYROIDS.

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With our forebears, anatomy was the handmaiden of surgery; pathology its judge or jury. Modern aggressive surgery, the veritable *sectio in vivo,* demands of the anatomist a closer study of the viscera and ever and anon puts new problems before the physiologist.

The enormous amount of anatomic, embryologic, physiologic, chemical and animal experimental work on the thyroids and the parathyroids, growing out of the recognition of definite groups of postoperative symptoms, has shed much light on, and aroused much interest in, the functions of these important structures. I may not venture, because of the necessarily limited time alloted to this paper, to give even a cursory epitome of modern research work, but may attempt to state the conclusions which, after a fairly complete review of the work done by hosts of experimenters and observers, and my own limited part therein, appear to me to logically present the present status of the subject.

EXPERIMENTERS NOT UNANIMOUS.

It is but fair to state that some observers and experimenters of note are not in accord with the majority of workers and the conclusions currently accepted. Vincent and Jolly say that neither the thyroids nor the parathyroids are to be considered as organs essential to life. Rats and guinea-pigs do not seem to suffer from the extirpation of the parathyroids; monkeys show only

transient symptoms; dogs, cats, foxes and prairie wolves frequently suffer and die. On the other hand, badgers (purely carnivorous animals) are not affected by the operation. When parathyroidectomy proves fatal it is probably due to severe injury done to the thyroid. The thyroid and the parathyroids are to be looked on as a single physiologic apparatus, the two kinds of tissue being intimately associated embryologically and working together physiologically. When the thyroid is removed the parathyroids appear capable of functionally replacing it to a certain extent and their histologic structure changes accordingly.

Blum says the thyroid is no secretory gland, but a detoxicating organ, which by the removal of toxic material from the circulation by intraglandular detoxication exercises a protective power on the central nervous system. The thyroid has especially the power of splitting off iodin. The iodin stored in the thyroid never leaves the boundaries of that organ. Blum can not subscribe to the prevalent view that the parathyroids play a separate and distinct rôle. He accepts the dictum of Kishi, who says morbus basedowii can not be the result of hypersecretion of the thyroid, since the thyroid normally produces no secretion. The assumption of thyroid insufficiency alone can justify the foregoing observation. Basedow's disease must be treated by a diet free from meat. Kishi claims that his therapeutic results are as good as those obtained by surgical measures and, being without danger, are to be preferred. According to his view, the operation which reduces the thyroid mass is to be abandoned.

VIEWS GENERALLY ACCEPTED.

The large majority of writers hold views opposed to the foregoing. The views entertained at present are that the thyroid and parathyroids differ embryologically, histologically, anatomically and functionally. The removal of all parathyroids in man and in many ani-

mals is followed by tetany and death; the removal of the thyroid by chronic nutritive disturbances which make up the picture of cachexia strumipriva, eventually ending in death. Erdheim's experiments on rats for the demonstration of the consequences of the destruction of the parathyroids led him to assert that not the loss of thyroid substance but the destruction of the parathyroids is followed by tetany, and he furthermore was able to prove that in three cases of strumectomy, followed by tetany, the parathyroids were wanting or had been destroyed. McCallum in his experiments on dogs found tetany to follow the removal of the parathyroids, and so did a host of noted observers. Death from complete parathyroidectomy may be deferred for a time by feeding with beef parathyroids, and acute tetany entirely prevented, as demonstrated by Halsted, McCallum, Beebe and Rogers. Feeding with thyroid extracts or iodin-containing albumins, iodothyrin and similar preparations will overcome many symptoms of cachexia strumipriva and prolong life. After the removal of the thyroid gland the parathyroids never change structurally, never get to be like, never resemble thyroid tissue and never assume its functions. The removal of both is followed by death, the chronic symptoms perhaps predominating.

ANATOMY AND PHYSIOLOGY OF THE PARATHYROIDS.

The knowledge of the anatomy of the parathyroids and their arterial supply has by the labors of Halsted, Evans, McCallum and others become quite exact. On a few points the observations differ slightly. First as to the number of parathyroids in man; four is the usual number; there may be fewer and occasionally one more. Verebely found four parathyroids in 108 out of 138 autopsies. Thompson and Harris in 250 routine autopsies in the St. Louis City Hospital found four parathyroids in 90 per cent. of the cases. They also found in their experimental work that the symptoms resulting

from slow deprivation of functionating parathyroid tissue differ materially from those following extirpation of the glands. The slow deprivation of functioning parathyroids was produced by as complete devascularization as possible. The animal (in their cases the dog) dies eventually; but instead of the acute tetanic death which follows excision, with slow destruction of the glandules, the animal loses in weight and strength, disturbances of a trophic character ensue, and finally a comatose condition ends the scene without tetany.

These observations are not quite in accord with the presentation of the subject in the classical article on "The Parathyroid Glandules, Their Blood Supply and Their Preservation in Operation on the Thyroid Gland," by Halsted, an article which has been closely studied and much quoted. Halsted distinctly warns against interference with the parathyroid arteries, whether coming directly, as they usually do, from the inferior thyroids or from the channel. Ernst Hagenbach, in his valuable contribution on "The Function of the Thyroids and the Parathyroids," finds that injury or destruction of the parathyroid arteries of one side is followed by a passing tetany, then cachexia and death by cachexia; destruction of the arteries of both sides results in death in acute tetany; removal of the thyroid and of the inner parathyroids, saving the external ones produces no tetany but the development of cachexia; secondary removal of the external parathyroids causes death from tetany.

RELATIONSHIP OF THE DUCTLESS GLANDS.

Recent studies of the ductless glands or organs producing an internal secretion, hinting at the intimate interdependence of the thyroid, the parathyroids, the adrenals, the glandular part of the pituitary body, the liver and the pancreas, seem to show that the physiologic rhythm of the body demands the integrity of all. A pathologic condition of one of them calls for an at-

tempt at a *restitutio ad integrum*—unless some other organ vicariously assumes its function — an attempt, aiming in fact at a therapeutic ideal, not reached by the method which removes or destroys.

Take, for an illustration, exophthalmic goiter. The thyroid has been proven to be a gland deserving to be ranked as a vital organ. The best results have been obtained, we all believe, by the removal of one-half or three-fifths or, with the saving of the parathyroids and their arterial supply, of nearly the whole of the gland. Injury to the parathyroids has been for a time atoned for by feeding with beef parathyroids, with Beebe-Rogers serum, or the transplantation of parathyroid tissue into the spleen, culminating in the beautiful and logical method of Halsted. Similarly, removal of too much of the thyroid has been counterbalanced by the administration of thyroid extracts or iodin-containing albumins.

NONOPERATIVE TREATMENT.

Measures other than operative may favorably influence some symptoms or the condition. A patient of mine, who was in a most miserable condition with a pulse of 190, delirium cordis, exophthalmos, loss of weight, and muscular tremors improved for a time by the application of ice to the neck and the region of the heart, by absolute rest, a diet free of meat, and belladonna administered for three weeks. The patient gained in weight, the exophthalmos improved, the pulse came down to 100. The patient assumed that he was almost cured. He returned to the hospital after two weeks in almost as bad a condition as before. A repetition of the above outlined treatment improved him sufficiently to prompt me to obtain a permanent result by an operation described later. We have not yet found the non-surgical treatment which gives satisfactory results, although Blum in a rather recent article asserts the opposite.

Professor Guthrie of Washington University, St. Louis, in whose experimental work on the vascular sys-

tem I have been much interested, included in his experiments work on the thyroid of the dog, and a number of specimens show the results of the reversal of the circulation and the ligation of the arteries and veins. In ligating the veins of the thyroid in dogs he showed that at first, for perhaps three days, there results an edematous swelling of the gland, followed soon by reduction to the normal and finally a small reduction in size and a slightly increased firmness. The dogs then invariably gained in weight. With these proven facts as a basis, the following suggested itself to me. In exophthalmic goiter we have an enlarged gland, an enormous increase in vascularity and capillary dilatation, a multiplication of the thyroid cells with abnormal activity, the presence of a great number of indifferent or vagrant cells and a peculiar change of the thyroid gland cells—the whole condition resembling a reactive process without physiologic termination.

PASSIVE HYPEREMIA BY SURGICAL OPERATION.

The plan then adopted, tried on several dogs, one a goitrous one, gave the results expected. I then tried it on the patient before mentioned. The plan rests on the following proposition: Ligation of the thyroid veins produces dilatation of the capillaries with increased pressure, transudation of blood plasma through the endothelial capillary tubes into the extravascular spaces until the pressure of the plasma in the intercellular spaces equals the pressure in the capillaries. We might count on the escape of some extravascular fluid by the lymphatics. The effect of the transudate at first is a mechanical one; there is a crowding of the cells, an interference with oxygen admission, the retention of carbonic acid, an asphyxia. In this condition the vagrant or indifferent cells, the least fit to survive, suffer a degenerative process and die, while the limitation of arterial afflux brings the gland cells from hyperactivity to the normal. As part of the process the connective tissue

stroma would increase and, in the later contraction, lessen the size of the gland—in other words, restore it to a condition near the normal. The result of the experiments on the dog distinctly demonstrates the success of the procedure, which in reality consists in the production of a Bier's passive hyperemia.

At a future time I shall publish the complete history of the case of my patient with observations during recovery and the final late effect. Objections to my suggestion may be made. At present I see one, surely not one to be regarded by the experienced operator; the infinitely greater difficulty of ligating the veins than the arteries. In my case I ligated both inferior thyroid and both superior thyroid veins. I am in doubt whether, on the right, I secured the trunk or only a large branch of the superior thyroid vein.

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DISCUSSION.

Dr. C. H. Mayo, Rochester, Minn., said that the study of the thyroid gland could not be dissociated from that of the parathyroid, thymus, pancreas and adrenal, and, probably, the pineal gland also. The thyroid had the most beautiful circulation in the body, with the exception of the brain; it would be impossible to destroy it except by deliberate act. At one time the thyroid undoubtedly delivered its secretions into the alimentary canal through a duct, and that was why the feeding of thyroid does so much good in some cases. Dr. Mayo said that Dr. MacCarty had made a classification comprising practically all goiters other than malignant; fetal thyroid; fetal activity; then, again, the normal gland activity; retention secretions; and then the degenerative conditions. So much had been written concerning the parathyroids that the surgeon, in any operation in the neck, feared that he might injure a parathyroid. Dr. Mayo said that in operating on over seven hundred goiters he had not had a single case of tetany. In 1896, in three cases, he had removed one parathyroid on the back of the gland. He did not know how many he might have taken out before that, but no symptoms were manifested in the cases where he knew that he had cut a parathyroid. Therefore, Dr. Mayo thought that the functions of these glands must be associated with other conditions. He did not believe that it was quite as serious to remove one of these parathyroids in the exophthalmic type of goiter as it would be in the old simple colloid goiter or diffuse adenoma.

Dr. Mayo thought that the operation of ligation of the veins, producing passive hyperemia, which Dr. Tuholske had brought forth, was in the right line in certain cases. Operation was the rule in these cases of hyperthyroidism—and that was the term which should be applied to all of these cases.

Dr. Mayo said that the history of these cases and the classification of the disease from symptoms had been made without any foundation in fact. One spoke of Graves' disease, first described in 1835, of Basedow's disease, first described in 1840, or Parry's disease, first described in 1825. Two symptoms, exophthalmos and goiter, had been taken as of prime significance, whereas 80 per cent. of cases would present either one or both symptoms, and 20 per cent. might show neither the enlarged thyroid nor the exophthalmos. Prior to the appearance of these symptoms, Dr. Mayo said, these patients would be treated for heart disease. The nerve specialist would prescribe rest. The enterologist would call the case one of gastritis and enteritis, and order white meat of chicken and no oysters for the patient. Another treatment which Dr. Mayo said had been advocated was the injection of antitoxin. One might almost read the entire pharmacopeia to cover the history of the treatment of hyperthyroidism. If a patient with heart disease had protruding eyes, Dr. Mayo said, the case was diagnosed as exophthalmic goiter.

He said that ligation should be done in three types of cases. It should first be recognized that 25 per cent. of patients would recover with, without, or in spite of treatment. In very mild cases, which did not justify the removal of half the thyroid, a simple operation of ligating one or both superior thyroid arteries and veins should be done. Another type was so dangerous that there might be a degenerated heart muscle, possibly brown atrophy with soft spleen, with nephritis albumin in urine, and fatty degeneration of liver. The physician might be afraid to operate. If under cocain anesthesia, ligation of first one artery and then the other, with the accompanying vein were done, Dr. Mayo said, the patient would improve. In another type of cases the right and middle lobe would perhaps be extirpated and the patient would improve; if there was insufficient improvement, or a relapse, it should not be considered a mistake to have operated on that thyroid. Ligation of the superior thyroid artery and vein on the other side would have a remarkably good effect in such cases.

Dr. Mayo said that last January he and his colleagues had gone over the last 200 cases of exophthalmic goiter and sent out 190 letters. (Ten patients, 5 per cent., had died from operation.) They had received 167 answers to these letters. Seventy per cent. of the patients were cured, and 89 per cent. had either been cured or greatly improved. A few more cases brought the percentage up to 94 per cent. cured, greatly improved or somewhat improved. Some were not improved at

all. In some cases, Dr. Mayo said, surgery could do anything but many of these cases were treated so long medically that the burden of surgical mortality was of necessity much greater than it should be; it ought to be called medical and surgical.

DR. A. J. OCHSNER, Chicago, said that there was no operation in the entire field of surgery in which the importance of knowing when and how was greater than in this particular operation for exophthalmic goiter. The surgeon did well to operate when the patient's condition was at a standstill or, in general, reasonably good, so that resistance to the slight shock of operation might be counted on. When there was no resistance left, the results of operation would be exceedingly bad. Dr. Ochsner mentioned another class of advanced cases in which the other organs of the body still were sufficiently good, so that if the patient's temporary condition were improved the immediate, as well as the late result, would be good because the absorption of the thyroid secretion would be stopped. Recovery, however, would be slow. Dr. Ochsner said that much had been learned from Kocher, Mayo and others; namely, that in the operation itself the patient could be protected, first, by reducing the trauma; second, by preventing shock, especially in cases which have gone too long before operation, and by performing preliminary operations in these cases, such as Dr. Tuholske and Dr. Kocher had recommended, or by following the method of Charles Mayo, of dividing the operation into two stages. There was no operation in surgery that had improved so much during the last ten years, both as regards the choice of time and the number of operation as this one.

CHRONIC PANCREATITIS.

JOHN B. DEAVER, M.D.
PHILADELPHIA.

Perhaps the most important advances in abdominal surgery of recent years have been those made toward the elimination of digestive disorders, that is, the recognition that by surgery we are able to attack successfully not only the acute and obvious lesions, such as acute appendicitis or intestinal obstruction, but also those dependent on more obscure lesions of the stomach, biliary system and pancreas.

As the importance of the pancreas in the process of digestion was recognized by pathologists long after painstaking investigations had served to bring us to an understanding of gastric and intestinal physiology, so also the surgery of pancreatic conditions has been considerably behind that of the other abdominal viscera.

This is due to a number of reasons. The pancreas is deeply situated and almost inaccessible for direct surgical interference. Its functions being but little understood, their derangements naturally were not recognized, and those finer tests in physiology were as yet unknown.

The work of Fitz brought the attention of the profession to acute pancreatitis, but it was many years later that the chronic form of inflammation of this organ was clinically recognized, even though it had been pathologically studied by many observers.

PATHOLOGY AND ETIOLOGY.

As to pathology, chronic pancreatitis may be subdivided into the interlobular and the interacinar forms.

For the purpose of the surgeon it is sufficient to state that the most frequent form is the interlobular, and that it is this form with which we have to deal in the pancreatitis complicating disease of the biliary passages. The interacinar form is due to systemic conditions not yet understood and is therefore correspondingly unfavorable to direct or local attack.

The etiology of chronic pancreatitis is of the utmost importance. There is no doubt that its most frequent cause is some interference with the free discharge of the pancreatic secretion, either associated or unassociated with an ascending infection. As by far the most common cause of such obstruction is the lodgment of a gallstone in the ampulla of Vater, or other part of the common duct, the frequent association of the conditions is at once explained. The occurrence under such circumstances of a pancreatitis, either acute or chronic, is not inevitable, but it is very common. The damming back of the pancreatic secretion with dilatation of the ducts and interference with function is in itself sufficient to cause a chronic inflammation of the gland. Yet in most instances we have no doubt to deal also with an added infection ascending the duct of Wirsung and joining its action to the other cause of inflammation. If the infection be virulent, acute pancreatitis may supervene—if of diminished virulence, we have the chronic form of pancreatitis as a result.

When the duct of Santorini is so situated that it can take the place of the duct of Wirsung, the main duct of the pancreas, as an avenue of discharge, pressure on the duct of Wirsung does not bring about such dire results, yet an infection at the same time active may nullify this action and lead to a pancreatitis even in the absence of a marked stasis in the secreting ducts.

The feature of infection would account for those cases of chronic pancreatitis which we find in those cases of gallstone disease in which the stone does not actually occlude the common duct. The very presence of the

stones presupposes an infection of the biliary passages at one time or another, and when this is present there is little doubt that the whole biliary tract is involved. In a certain proportion of these cases the pancreatic duct would, of course, become infected also, and as the infection causing gallstones is known to be a subacute one—by some organism of diminished virulence—we have in the condition causing the gallstones one which also will cause a pancreatitis.

Indeed, most of my cases of chronic pancreatitis have, contrary to the general rule, occurred in patients in whom no gallstones were present. Yet in almost every case I could discern either the presence of an infection as shown by the bile, the congestion and an inflammation of the gall bladder, or the fact that there had been some cholecystitis, as evidenced in a shrunken and distorted gall bladder, or the presence of pericholecystic adhesions.

So while duct obstruction plus infection furnishes the most likely cause of chronic pancreatitis, either factor alone is sufficient to cause this condition. The rôle of infection alone is also demonstrable in those cases in which a chronic pancreatitis follows on a long-standing gastroduodenal catarrh. Several cases have come under my notice and have been reported by other surgeons. I have in mind particularly one case in which this was so, and in which the occurrence of the pancreatitis was directly traceable to a chronic gastroenteritis. It is important in these cases to bear in mind the fact that the supposed gastroenteritis thought to precede the pancreatitis may in reality have been its first manifestation instead of its precursor.

Blocking of the pancreatic ducts by calculi in them or by new growths of the common duct or the ampulla of Vater may be mentioned as among the rarer causes of chronic pancreatitis.

In some of my operations I have noted the association of a chronic pancreatitis with cirrhotic conditions of

the liver, and in a number of cases which have come to autopsy from the medical wards of the German Hospital the two conditions have existed together.

Many other causes of chronic pancreatitis have been claimed. At the German Hospital it has been found at autopsy in cases of cardiorenal disease, tuberculosis, pernicious anemia, syphilis and other conditions.

There is no doubt that were microscopic examinations made of the pancreas many instances of beginning change would be found in cases where the organ feels and looks entirely normal. It is a well-known fact among surgeons that in quite a few instances in which in life the pancreas is found to be markedly indurated and congested, at autopsy, held some hours after death, the organ presents no macroscopic evidence of disease and is entirely normal to the touch.

The diagnosis of chronic pancreatitis in life was thought some years ago to be impossible, except in those cases in which the metabolism was so greatly disturbed that evidences of this were most markedly shown in both urine and feces. As surgeons have had opportunity of studying the organ on the living subject at operation, we have come to associate certain clinical symptoms with a condition of chronic pancreatic disease, and it may even be asserted that a somewhat definite syndrome has been established. In spite of this, I can not agree with Mayo Robson when he characterizes it as being easy to diagnosticate. At the present time by far the majority of cases are unrecognized except at the operation or necropsy.

SYMPTOMATOLOGY OF THE DISEASE.

In considering the symptomatology we must remember that the symptoms are caused in three ways, and may thus be divided into three groups:

1. Those which depend on the local lesion, i. e., the local manifestations of disease in the upper abdomen. 2. Those which come as a result of the interference

with pancreatic secretion, i. e., a form of indigestion. 3. Those depending on interference with the internal secretion of the pancreas—shown principally in the occurrence of diabetes and in the pancreatic reaction in the urine.

1. *Symptoms Depending on a Local Lesion.*—The local symptoms are essentially unimportant as compared to the systemic ones. The patient will at times complain of some epigastric pain, occasionally localized somewhat to either side of the median line. Tenderness in this locality may also be present. The presence of a tumor has been described by some, but I have never been able to satisfy myself of the presence of this sign in chronic pancreatitis.

A general symptom, dependent often on local mechanical interference, is jaundice. We would naturally expect to find this in those cases in which the pancreatitis is associated with gallstone disease, but it occurs also when this is not the case. This in some instances is due to the partial obstruction of the common duct by swelling of the head of the pancreas and would be particularly liable to occur when the duct runs within the substance of the pancreas, as it does in about two-thirds of all cases. Occasionally the jaundice appears to have been a coincidence, i. e., to have been caused by cholangitis resulting from the gastroduodenal catarrh responsible for the onset of the pancreatic lesion.

Mayo Robson has lately offered the suggestion that many instances of catarrhal jaundice, especially of the chronic form, are due to a pancreatic lesion, i. e., that the engorged pancreas by pressure on the choledochus is responsible for the jaundice. This contention he has supported by the report of a number of cases in which the pancreatic disease was discovered by other tests; operation in all cases brought a permanent cure. I am not prepared to admit that all cases of catarrhal jaundice are pancreatic in origin. But the possibility should be borne in mind when we have to deal with forms of

the disease which are resistant to the ordinary medical and dietetic treatment.

At times the damming back of the bile will give rise to distention of the gall bladder, which organ may even become palpable. In these instances the symptom is more apt to confuse than to help us, as it would lead us to believe the condition to be primarily biliary. This, however, would not be of such moment, as surgical interference is indicated in either case.

The local signs, as I have stated, are in themselves not significant and gain importance only when associated with other signs of pancreatic trouble. The jaundice, of course, would give us a clue, but as often as not it, as well as the local signs, leads us to suspect disease of the bile ducts or cholelithiasis, when the lesion is in reality pancreatic.

2. *Symptoms Due to Interference with Pancreatic Symptoms.*—The digestive symptoms due to interference with the pancreatic secretion are of the utmost importance. The patients often have anorexia, fulness in the epigastrium and eructations of gas. Associated with these we often have diarrhea of an intermittent or continuous form, in which the stools are large and often grayish in color and contain an excess of free fat.

This combination of such an indigestion with the local signs of a lesion in the upper abdomen should lead us to suspect a pancreatic condition at once.

Occasionally we become aware of the presence of a chronic pancreatitis by an acute exacerbation. Several instances have come to my notice in which this was so, with history about as follows: The patient, previously in fairly good health, was taken ill with symptoms of a lesion in the upper abdomen; pain here was preceded by a chill and followed by marked prostration and cyanosis. These in turn were succeeded by fever with the development of a dulness in the upper left abdomen and lower part of the chest. The Cammidge tests, A and B, were both positive.

It is true that many other portions of the gastro-intestinal tract when diseased give us symptoms of indigestion, but each lesion will be found on close study to give rise to a more or less characteristic form. Thus, in chronic gastric ulcer we have pain after eating, vomiting, hyperacidity and a tendency to constipation. The stools show us no excess of fats and undigested muscle fiber as in pancreatitis, but often give us signs of hemorrhage—such as the occult blood test. The associated epigastric signs are also often more severe, and inflation of the stomach may at times show us a considerable degree of dilatation. Jaundice also is not found.

Chronic gastroenteritis or colitis may give us persistent or intermittent diarrhea. Yet the localizing signs are all to be found in the lower abdominal segment. The stools are often watery and they show us no evidence of impaired digestion of fats.

In chronic appendicitis, constipation and not diarrhea is the rule. The indigestion is usually of a less marked grade than in either pancreatic or gastric lesions and does not exercise such a deteriorating effect on the patient's health in general. Then again we often find a history of acute attacks of appendicitis, or else of chronic soreness and tenderness in the right iliac fossa. The stools also show nothing characteristic.

The emaciation and weakening which the indigestion of pancreatic disease brings with it is insidious in onset, but in late cases most marked and intractable and furnishes another symptom, if it may be so called. But when the disease has progressed to this stage the diagnosis as a rule interests us more as a curiosity preceding autopsy than as an indication for treatment.

In spite of the apparent distinctness of the symptomatology of chronic pancreatitis, its differentiation is not always easy. Its onset is often most insidious, and one or another point in the symptom-complex is not present. Jaundice may not occur; the local signs may be practically absent. The examination of the feces is at times

inconclusive and often demands skill in examination not easy to obtain.

Then again, in those cases in which the pancreatitis is associated with gallstone disease, the latter in almost all cases overshadows the often more dangerous pancreatic condition. And so well known are the symptoms of disease of the gall ducts compared to those of the pancreas that physicians are prone to consider the symptoms of a chronic pancreatitis as being the aberrant ones of cholelithiasis, even when the distinction is comparatively plain.

3. *Symptoms Due to Interference with the Internal Secretion.*—The third group of symptoms—those depending on disorders of metabolism, due to interference with the internal secretion of the pancreas—are really the most distinctive of all and give us the most definite basis for a diagnosis of pancreatic disease.

Diabetes has been long recognized as being often associated with pancreatic disease. Unfortunately, when this condition has supervened, the pancreatic lesion is often too far advanced for any marked improvement by any method of treatment, either medical or surgical. In some cases it must be remembered that the glycosuria is not due to a true diabetes resulting from interference with the internal secretion of the pancreas, but is due to the absence in the alimentary canal of its secreted ferments, and in some instances may be a pure alimentary glycosuria associated with pancreatic disease. It may be noted here that the interacinar form of chronic pancreatitis, affecting as it does the islands of Langerhans earlier than the interlobular form, is more apt to give us an early and intractable diabetes.

The reaction discovered by Mr. Cammidge I believe to be an aid in the diagnosis of pancreatic disease. It is true that the originator and his collaborators have been able to get more positive results from its use than others, but it has been found of value in many cases. I am inclined to regard it for the present, in the hands of

most investigators and laboratory workers at least, as a fairly constant sign of pancreatic disease, rather than of great value in the differential diagnosis.

It will be seen, then, that the majority of cases of chronic pancreatitis, either associated or unassociated with gallstone disease, may be diagnosed with a fair amount of certainty if sufficient care be taken. They are cases in which the history must be most carefully taken and the patient's memory for details at times taxed to the utmost. In conjunction with this the study of the urine and feces should be undertaken by one who is an expert. The results in this line of work by the unpracticed are more likely to be misleading and confusing than of any real aid to the diagnostician.

TREATMENT.

Granted, then, that the diagnosis of chronic pancreatitis has been made, or that chronic pancreatitis is discovered on the operating table, what should be our line of treatment?

It can not be denied that the efforts to benefit patients suffering from chronic pancreatitis by the use of pancreatic extracts, derivatives or substitutes have been futile in all but a few instances. In these the results have at times been remarkable, but the treatment is, as a rule, irksome, especially when a strict diet must be followed. Not only this, but as no effort is really made to restore the pancreas itself to function, its action by its internal secretion is lost, and in spite of the substitution of its ferments metabolic disturbances generally increase.

Medical treatment also is entirely unable to really reach and remove the cause of the pancreatic lesion—to give the pancreas a chance to functionate again the normal way. Surgery in many of these instances will enable us to attain a radical cure. It does this in two ways:

1. By removing the underlying cause of the pancreatitis when this is to be found in an obstructed choledochus.

2. By enabling us to overcome the infection in the biliary and pancreatic ducts.

When the pancreatitis is secondary to gallstone disease, as is the case in so many instances, removal of the calculi, together with free drainage of the bile ducts, in most cases leads to a complete subsidence of pancreatic symptoms. The obstruction being removed, the pancreatic ducts have an opportunity of again emptying themselves and the irritating bile is no longer forced into them by back-flow. The coexisting infection of the biliary passages is cured or rendered harmless by the drainage instituted at the time of operation, and thus the pancreas is enabled to take its place as the main factor in the whole cycle of digestion. The benefit to the chronic pancreatitis in many cases of gallstone disease doubtless accounts for the wonderful restoration to complete health of those patients who are found to be weakened and emaciated to a degree not explainable by the mere biliary condition.

When the gall ducts are found clear, and the infection which has given rise to the chronic pancreatitis has subsided, drainage of the organ by way of the biliary passages nevertheless exerts a remarkable curative effect on the lesion. This is especially true when the pancreatic condition is diagnosed and the patient operated on while it is in its incipiency, before the so-called catarrhal pancreatitis has really become a chronic interstitial interacinar lesion.

The choice of operation in dealing with chronic pancreatitis resolves itself into a decision between simple drainage of the biliary ducts or a cholecystenterostomy. I have used both methods, and each has its advantages in special cases. When gallstones are found in conjunction with pancreatic disease, or when the latter is

found during a gallstone operation, I consider the drainage indicated by the biliary condition to be sufficient. Thus, if we have stones in the choledochus, a choledochostomy should be performed in the usual manner. The operation of cholecystostomy is to be preferred when we find a pancreatitis the result of a still active infection of the bile ducts or when the pancreatitis is discovered in its incipient or catarrhal stage.

Cholecystenterostomy is indicated when the pancreatic condition is well advanced and we wish to procure permanent drainage. This operation is not my choice when much biliary infection is present, as I always prefer surface drainage when marked infection is manifest. This operation also I consider to be more grave than ordinary cholecystostomy, and I have found it to be attended by a higher mortality in my own operative work. Especially does this become true when we are dealing with a gall bladder not well suited for the procedure.

The indications for surgical interference in chronic pancreatitis I consider to be found in the diagnosis itself, unless some circumstance prohibits it. Thus, I would not operate in the presence of marked organic disease of other organs, nor would I be prone to advise operation in patients who are *in extremis*.

Moderate anemia and glycosuria are not contraindications to operation in pancreatic cases, as both are often greatly benefited when the metabolism of the body is restored to its normal status. My results in chronic pancreatitis have been such as to encourage me to further operative work in this direction. The immediate mortality is still quite high, due in large part to the extremely weakened condition of the patients, the grave associated conditions, and especially the tendency in those patients in whom we find both jaundice and a pancreatic lesion, to uncontrollable hemorrhage.

The details of the operative technic are not matters of extreme difficulty, and improvement in results must come from earlier diagnosis. In gallstone cases the patients should be operated on before chronic pancreatitis supervenes, and other cases of pancreatitis unassociated with lesions of the biliary passages should be recognized sooner than they now are.

PANCREATITIS IN ITS RELATION TO GALL-STONE DISEASE.

WILLIAM D. HAGGARD.
NASHVILLE, TENN.

The pancreas is the most sequestered organ in the body and has only recently yielded up, in part, the secrets of its incorrigible inflammations. The clinical knowledge of its pathology has been obtained in operations on the gall tracts. Its natural history has been unraveled and, while in the past its recognition has been uncertain, it can now be identified during life in a considerable number of instances, both in its acute and chronic form. It is important in all operations on the upper abdomen that the surgeon should examine with detailed care the head of the pancreas, not only to determine the existence of pathologic changes, when present, but also to appreciate the "feel" of the normal gland. The fact that the Mayos found the pancreas to be involved in 6 per cent. of all the operations on the gall tracts is sufficient indication of its importance, as well as of the causal relation between gallstones and diseases of this neighboring gland. They further found 81 per cent. of pancreatic diseases to be the result of, or coincident with, gallstones. Egdahl regards biliary lithiasis the most frequent single cause. Osler says that forty-five out of one hundred and five cases were associated with gallstones. Robson found pancreatic implication in 60 per cent. of cases in which gallstones were in the common duct. Out of 118 cases Quénu and Duval in 46 cases found stones in the gall bladder or cystic duct; in 20 cases in the common duct; in 8 cases

in the ampulla of Vater; in 2 cases in the duodenum, near the ampulla; in 28 cases in the entire tract; in 10 cases undetermined, and in 3 cases in the stools. Mayo observed pancreatitis to be four times as frequent when the stones are in the ducts as when they exist in the gall bladder (18.6 to 4.45). The head of the gland is involved seven times as often as the entire gland (124 to 17). Nearly two-thirds of common ducts are surrounded by the head of the pancreas, which, if swollen, causes obstructive jaundice. In the other one-third an independent opening of the duct of Santorini may act as a safety valve.

Opie discovered the rôle which a small (pea-sized) stone lodging in the ampulla of Vater plays in converting the common and pancreatic ducts into a through channel, allowing bile to be injected directly into the pancreas and thus produce the acute type of infective and hemorrhagic pancreatitis.

Robson has established on an indefensible basis the relationship of gallstones in the common duct and chronic interstitial pancreatitis. It is probable that stones simply render the organ more vulnerable to bacterial invasion.

Flexner asserts that modified bile, with diminished salts and increase in colloid, sets up chronic pancreatitis. Fresh and unaltered bile gaining entrance to the pancreas begets acute changes. If an impacted gallstone does not cause bile to enter the pancreas direct, simple obstruction and retention of the pancreatic secretions, if infected, will cause inflammation.

Desjardins thinks that micro-organisms find their way through the duct of Santorini into the Wirsungian duct and back into the duodenum, thus causing infection in the "triangle of inflammation" when there is obstruction. This could not occur in one-third of the cases for in 21 per cent. the duct of Santorini is impervious and in 10 per cent. it does not communicate with the duct of Wirsung.

Regurgitation of fatty materials from the duodenum into the duct where it had been dilated from the previous passage of a gallstone has been suggested by Hess as a causative factor.

Robson operated in fifty-two cases of the chronic interstitial type which were due to gallstones and in forty-six cases in which there were no gallstones. Of this latter group it has been said that gastrointestinal disorders caused about 30 per cent., of which one-half are in alcoholics. Among other causes which have been mentioned are typhoid fever, pyemia, malaria, mumps, appendicitis, trauma, embolism, gastric or duodenal ulcer.

The acute type is so sudden and severe in its onset, attended with such agonizing pain and followed by such extreme prostration that it has been denominated "the pancreatic drama." The pulse is rapid with rise of temperature. Vomiting occurs at once and is persistent. First, the stomach contents are regurgitated, and then the intestinal, simulating acute obstruction, although gas is passed. The lips are livid, the extremities cold, the entire body of a cyanotic leaden hue. Dyspnea is often present and constant splitting backache has been observed (Erdman). The pain is excruciating, paroxysmal and deep seated and is uncontrollable with ordinary doses of morphia. Collapse is extreme. Tenderness is diffuse, and the whole picture is that of "the acute abdomen." There is some epigastric induration in the first twenty-four hours, but the consecutive distention soon obliterates it. There is no glycosuria. Erdman and Thayer found no sugar in five cases each. Patients die in collapse in forty-eight to seventy-two hours. This type occurs oftenest at about the age of 50, in fleshy subjects addicted to alcohol.

Acute peritonitis from perforation of viscera is closely simulated. The actual diagnosis is very inexact. Of fifty cases, twelve were diagnosed as perforating gastric ulcer; twelve as intestinal obstruction; four as acute peritonitis; two as appendicitis; two as cholecystitis;

one as strangulated hernia; one as angina pectoris; in eleven no diagnosis was made and in the remaining five the diagnosis of pancreatitis was correctly assumed. Fortunately the operative indication is equally imperative in most of the conditions which appear to be in evidence. Owing to the extreme fatality the operation is urgently demanded. Ebner says that out of ninety-six patients 90 per cent. who were not operated on died, and of those operated on 52.8 per cent. survived. Körte saved six patients with fat necrosis.

The laboratory examinations of the urine and feces are so laborious and consume so much precious time in the acute cases and are really so inconclusive that it does not seem wise to delay exploration to have them made.

The distinctive tissue change is fat necrosis. It results (when there is obstruction) from penetration, into the tissues adjacent, of pancreatic juice and certain ferments, which split the fat into its component fatty acid and glycerin. The latter is absorbed and the former unites with the lime-salts to form yellowish-white non-elevated opaque spots about the size of a millet-seed that look like droplets of candle grease. Fat necrosis points as unerringly to the pancreas as jaundice does to the liver. There is also marked exudation. The colon and omentum are gorged with fluid. In the omentum there have been observed clumps as large as sausages (Brugsch and König).

In the subacute or suppurative form the onset is less sudden and severe. Chill, fever and leucocytosis are present and an epigastric tumor gradually develops. Although constipation is the rule, fatty stools and occasionally fragments of necrotic tissue may appear. A less violent course is pursued, sometimes ending in resolution. These cases frequently terminate in suppuration, which burrows in a bizarre way. Operation is not so immediately necessary in the subacute cases unless suppuration demands evacuation.

Chronic pancreatitis occurs in individuals with previous painful epigastric attacks which often declare their gallstone origin. There is midline tenderness, slight fulness, pain referred to the left side, to the kidney and left scapular region. There is extreme loss of weight which, with the pigmentation of the skin, frequently gives rise to the inference of malignant disease. Jaundice is commonly present and may exist for many months. Nearly all cases of so-called catarrhal jaundice are in reality pancreatic catarrh or actual chronic pancreatitis. The intense irritation of the skin in jaundice is indicative of pancreatic and not biliary origin. The common duct is surrounded in the lower third of its course by the head of the pancreas in 62 per cent., which when swollen produces obstructive jaundice. In 38 per cent. the duct runs behind the pancreas and, although it might be enlarged, no pressure jaundice will result.

Uncomplicated gallstones are most easily identified by their early history. Typical attacks, without jaundice, then attacks followed by jaundice and attended with ague-like symptoms with no tumor, betoken the lodgment of stone in the choledochus. In chronic pancreatitis induration is often made out, and the tenderness is central rather than under the right arch. Gallstones that do not encroach on the common duct do not give the pancreatic urinary reaction of Cammidge and the feces are alkaline. In pancreatitis the motions contain large quantities of undigested food and are greasy because of the unsaponified fat. They are light in color and bulky.

In chronic pancreatitis Schmidt's bag test is said to show the nuclei undigested in the meat fibers of a small cube which is sewn in a silk bag that is taken into the stomach and recovered from the stool.

In many instances the head of the pancreas has felt like cancer at the time of operation and has been so diagnosed, but the patients have really been cured by removal of the stones and drainage, showing the induration to

have been an interstitial thickening of the pancreas. Still it is quite possible in many instances to detect the late cases of cancer without operation. The condition lacks the acute onset, pain and fever. The gall bladder rapidly becomes distended. The feces quickly turn white. There is hematemesis and melena and, lastly, the enlargement of the cervical glands, ascites and edema.

Degenerative changes in the pancreas may destroy its control of the metabolism of carbohydrates and produce diabetes. It rarely occurs in the interlobular form of pancreatitis, but almost uniformly in the interacinar form when the greater part of the gland is replaced by scar tissue which crowds out the cell-islets of Langerhans.

Sugar was found by Cammidge in 6 per cent. of Robson's sixty-five cases of common duct stone.

While diabetes is not a common result of gallstone pancreatitis, it may happen that delayed operation will permit an ordinary interlobular type to advance into the interacinar form with its tell-tale glycosuria.

The operative indication for the acute cases is unmistakable. Incision of the acutely inflamed pancreas with drainage often suffices. The peritoneum should also be drained when there is that peculiar beef-broth serum present. If the patient's condition permits the complicating gallstones should be rapidly removed and drainage instituted.

In the chronic cases drainage of the bile passages, while indirect, is most effective. It is an anomalous illustration of a palliative operation being also a curative one. A thorough search with finger and probe after the removal of the obvious stones is essential to insure none being left. It is especially difficult to detect them in the pancreatic portion of the duct. The common duct is best drained temporarily with a catheter introduced up to the junction. Permanent drainage is to be established by cholecystenterostomy if there are no gallstones. Sidney Phillips observed a disagreeable diarrhea when the

gall bladder was attached to the colon, but in two instances I have seen no unpleasant symptoms. The duodenum, instead of the colon, is undoubtedly more desirable, as it delivers the bile into its natural channel where it is physiologically needed.

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DISCUSSION

ON PAPERS OF DRS. DEAVER AND HAGGARD.

DR. ARTHUR DEAN BEVAN, Chicago: In the development of this new surgery of the pancreas, members of this Association have played the most active part. I refer to the memorable work on pancreatic cysts by the late Nicholas Senn; the splendid work on acute pancreatitis by Fitz, and the pathology of the pancreas by Opie.

In connection with injuries of the pancreas, two things have impressed me as being of great importance. First, the diagnosis can not, as a rule, be made without an exploratory laparotomy, which is best made under gas anesthesia. Second, we must provide for most thorough drainage and also for thorough protection of the abdominal wall against the digestive action of the pancreatic juice. The latter, I think, is best done by oxid of zinc paste.

In acute pancreatitis the diagnosis, although difficult, is by no means impossible. In a general way those cases which have a clinical picture midway between ileus and perforation, with a definite line of tenderness in the pancreatic region, and some swelling, are very suggestive of acute pancreatitis; but the diagnosis must be made by exploratory operation under gas anesthesia. It is not always necessary to interfere in these cases. In three of my cases the operation was purely exploratory. A definite diagnosis of acute pancreatitis was made. There was no definite swelling nor any evidence of suppuration in the region of the pancreas; no gallstones to remove, and I simply made the operations exploratory, with immediate closure of the wounds, and all three patients went on to recovery. On the other hand, where there are gallstones they should be removed, and if there is swelling and evidence of hemorrhage and suppuration. drainage should be instituted.

A most interesting group of cases are those in which it is impossible to differentiate between carcinoma and chronic interstitial pancreatitis. I think that here the rule should be to take the optimistic side. Three times in one winter I made the brilliant diagnosis in my service at the Presbyterian Hospital, after exploratory operation, of carcinoma of the pancreas and very gravely told the relatives of the diagnosis. We sent the patients home to die. Those three patients went

on to perfect and complete recovery after cholecystenterostomy. That has been a most instructive thing to me, and now I take the optimistic side in these cases and do a cholecystenterostomy with the hope that the case may be one of chronic interstitial pancreatitis and not carcinoma.

Dr. Carl Beck, Chicago: The coincidence of pancreatitis and gallstones is by no means rare or exceptional. The numerous reports of the coexistence of these two pathologic conditions, the large number of experiments on animals, and the clinical observations prove the truth of these two statements. The reason why of late we understand a little more about these conditions is that we now make our diagnosis of pathologic conditions at the operating table and not at the postmortem. The erroneous views of former times were due to the examination of this organ postmortem. The tissues of no other organs undergo such rapid changes as do those of the gall bladder and pancreas. The diagnosis of diseases of the pancreas is difficult, and we hailed the Cammidge test with enthusiasm as a great help; but there is only one means of making a definite diagnosis, and that is by exploratory operation.

At the present time the position of the surgeon relative to this question of pancreatitis and cholelithiasis can be summed up in four points: First, knowing the great danger of acute pancreatitis, leading to abscess or fat necrosis, every time acute pancreatitis is suspected an exploration must be made, even during the attack. The dangers of hemorrhage and perforation are insignificant compared with the danger of acute pancreatitis. Second, in all cases of gall-bladder operation an examination of the pancreatic field should be made, and if a threatening abscess or necrosis is found, this part should be drained through the foramen of Winslow or gastrohepatic omentum backward, according to the nature of the case and the findings. Third, in all cases of acute pancreatitis and fat necrosis the gall tracts must be examined carefully for stone on acount of the common existence of gallstones with pancreatitis. Fourth, there are no other means at present of saving the patient's life except thorough drainage forward toward the abdominal wall and backward.

Dr. William L. Rodman, Philadelphia: It has been made very clear to us in these admirable papers that it is practically impossible by the clinical symptoms and signs always to diagnose diseases of the stomach, and that even after a laparotomy it is not always possible to differentiate between benign and malignant disease. We have all accepted these conclusions so far as the stomach is concerned, and we have practically agreed in view of this difficulty of making a diagnosis between the several affections of the stomach that it is better to err on the safe side in our practice, and do a more radical procedure when it can be done without materially in-

creasing the risk. It seems that what is true of the stomach and gall bladder and ducts is just as true, and in a way truer, of the pancreas. I thoroughly agree that it is simply impossible to diagnose at all times either acute, subacute or chronic pancreatitis. In one case after exploring the pancreas and being positively certain that I was dealing with malignant disease of the stomach, I closed the abdomen, after establishing drainage of the gall bladder, and found a tumor the size of a fist at the head of the pancreas. The patient's jaundice soon passed away; he rapidly gained in weight, and now, three years after the operation, is perfectly well.

Chronic pancreatitis is a more common disease than we have thought it was hitherto. In the great number of operations that are being done at the present time on the gall bladder and ducts, we should take care lest too radical surgery be done in the way of removing the gall bladder, unless it is absolutely necessary, because the only successful way of treating chronic pancreatitis is by drainage. If cholecystectomy be done where cholecystotomy would have answered all indications, and the patient subsequently develops marked pancreatitis, what is to be done? Of course, we can, as Robson does, drain the common duct, which acts as a gall bladder, but this is a far more radical procedure than draining the gall bladder itself. Therefore, it seems to me that the lesson to be drawn from these papers and discussions is that we should practice more conservative treatment of the gall bladder in doubtful or borderline cases that come to us. Dr. Deaver has drawn particular attention to the fact that the two conditions are often associated and that they can not be differentiated. This is just what we ought to understand, when we reflect on the anatomy of the pancreas, and the fact that these stones often coexist in the pancreas and the gall ducts. A stone in the common duct will cause retrojection of bile into the pancreatic duct or the duct of Wirsung, and pancreatitis may follow. In a recent case of acute pancreatitis the symptoms markedly simulated those of acute intestinal obstruction.

Dr. William H. Wathen, Louisville, Ky.: It is almost impossible to make a positive diagnosis of acute pancreatitis and differentiate it from some disease of the right hypochondriac region. Until we have made an exploration we may resort to an analysis of the urine and not find pancreatic disease. We may find pancreatic disease where there is a reasonably good digestion of the products of food by these secretions, but we do know from what we have learned that the symptoms are sufficiently significant in every case to indicate an exploration; that by this exploration we can, as a rule, make a sufficiently accurate diagnosis to enable us to recognize these cases, and that the treatment is nearly always complete drainage. The practice of removing these structures is now rapidly becoming

obsolete. Drainage and the removal of any obstruction in the duct are indicated. Hence the failure to make a perfect diagnosis of disease of one of these structures is not of much importance, provided that we know that the exploration is necessary, and that we institute the proper treatment.

Dr. John B. Deaver, Philadelphia: Doctors must study their cases of indigestion more thoroughly. They must not be satisfied with diet and drugs in many of these cases. I called attention particularly to the class of acute pancreatitis, and especially the acute exacerbations occurring in the presence of chronic pancreatitis in which no drug is doing more harm than morphin given indiscriminately. Too many doctors when called to see a patient with pain in the abdomen are apt to resort too quickly to the hypodermic syringe. A physician might as well give his patient hydrocyanic acid. A prominent citizen of Philadelphia recently died of pancreatitis because he had morphin shoveled into him. That is the harmful effect of morphin.

Dr. W. D. Haggard, Nashville, Tenn.: One of the diagnostic symptoms of acute pancreatitis is that you can hardly give enough morphin to stop the vomiting, backache and pain. It is one condition in which morphin does not absolutely mask the symptoms. I urge the withholding of the drug and the wisdom and importance of operating early in most acute abdominal cases. When the abdomen is opened and fat necrosis is found, it will invariably point to the presence of pancreatitis.

ULCER OF THE DUODENUM,

WITH REPORT OF TWO HUNDRED AND SEVENTY-TWO OPERATIONS.

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The surgical invasion of the upper abdominal region has gradually enabled us to replace theory with facts, and fallacious clinical observations have given way before actual demonstration of diseased conditions.

One of the most striking illustrations of this newer knowledge is the discovery that three-fifths of all gastric and duodenal ulcers are situated in the duodenum. Until within recent years gastric ulcer has been considered the chief lesion, while reference to a duodenal location has been infrequent.

In a paper read before the American Surgical Association, May, 1904, I was able to report 58 operations for duodenal ulcer, which at that time was 27 per cent. of all the ulcers of the stomach and duodenum on which we had operated.

Two years later, in a paper read before the Surgical Section of the British Medical Association, August, 1906, on "Duodenal Ulcers," our statistics showed about 40 per cent. of ulcers in the duodenum. Since that time more careful investigation places the proportion at above 60 per cent.

In 1906-7 the total number of gastric and duodenal ulcers operated on by us (C. H. and W. J. Mayo) was 193. Of these, 119, or 61.7 per cent., were duodenal, 60, or 31 per cent., gastric, and 14, or 7.3 per cent. of

the patients had a separate ulcer on the stomach and on the duodenum.

This does not prove that duodenal ulcers are more frequent now than in the past, but rather that they have been confused with gastric ulcer. In other words, we have in the majority of instances been talking about gastric ulcer, writing about gastric ulcer, and treating patients for gastric ulcer, when the trouble was primarily in the duodenum and not in the stomach.

There are several reasons why the facts in regard to the relative frequency of gastric and duodenal ulcer have not been brought to light. Until of late our most important source of information was derived from post-mortem examinations, but such data are often misleading, since by the time the lesion had caused death terminal infections and secondary complications had so obscured the field that the situation of the ulcer could not be accurately determined and it was taken for granted that its location was in the stomach.

The greater number of patients with ulcer of the stomach and duodenum do not die from the disorder itself, but become a prey to intercurrent disease to which their underfeeding and consequent anemia renders them peculiarly liable.

In our earlier work even surgical exploration did not always reveal the truth, and often the location of the ulcer was not accurately established at the time of operation. This is accounted for by the fact that nearly all duodenal ulcers exist in the first inch and a half (ascending part) of the duodenum and more than one-half extend up to or within three-fourths of an inch of the pylorus, while 20 per cent. of them involve the margin of the stomach at the pyloric ring. Many duodenal ulcers, therefore, were formerly put down as pyloric and consequently classed with the gastric.

Differential diagnosis at the operating table between ulcers of the duodenum and those of the stomach near the pylorus may be difficult, but if careful search is

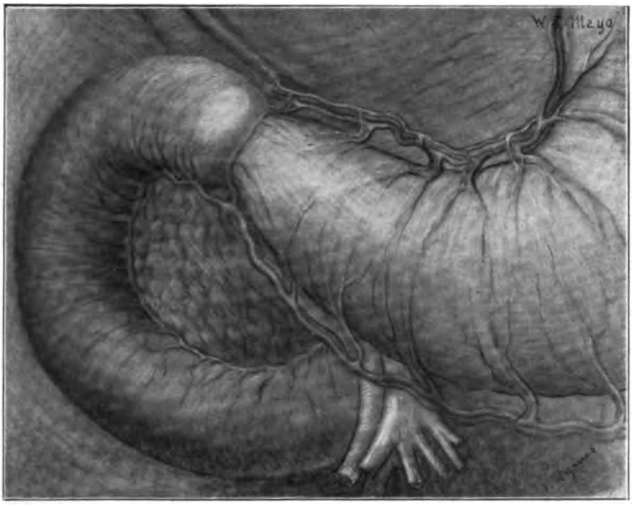

Fig. 1.—The anatomy of the duodenum with special reference (1) to the pyloric veins which accurately locate the pylorus; (2) note the light colored spot on the duodenum just below the pylorus, which may be mistaken for an ulcer when rendered anemic by traction; (3) crossing of the third portion of the duodenum by the superior mesenteric vessels.

made for the pyloric veins (Fig. 1), their exact location can be quickly detected.

Multiple ulcers of the stomach and duodenum are rare. In only 8.2 per cent. were there separate and distinct ulcers of each organ, although on the mucous membrane opposite an ulcer a second ulcer is often found at the point of contact, which we have, therefore, called the *contact ulcer*.

The total number of operations for duodenal ulcer is 272, made on 261 patients. Of these 77 per cent. were males and 23 per cent. females. The preponderance of male over female is hard to explain and is somewhat greater in duodenal than of gastric ulcers.

During 1906-7 60 patients with gastric ulcers were operated on, of whom 36, or 61 per cent., were males, and 24, or 39 per cent., females. In this connection it is worthy of note that, while nearly four patients out of five with duodenal ulcer were men, the opposite was true in gallstone disease, in which more than four out of five patients were women.

A somewhat careful examination of the living subject leads us to believe that, so far as duodenal ulcer is concerned, mechanics may play a part. The first, or ascending, portion of the duodenum in man seems to ascend a little higher than the average first portion in woman; consequently the alkaline, biliary and pancreatic secretions may rise higher and more readily neutralize the acid chyme in the first portion of the duodenum in women than in men.

In an early state of fetal existence the duodenum above the common duct is a part of the pyloric end of the stomach. Coming from the primitive foregut, it is associated with the stomach in its physiology and pathology and is not a part of the small intestine, which comes from the midgut. The embryonic stomach is rotated on its right side, and its original posterior wall becomes the greater curvature. The primitive anterior wall, which has become the lesser curvature, retains its

normal shape, but a pouch is formed by an expansion or dilation of the primitive posterior wall (greater curvature), and this becomes the fundus or storage end of the stomach. The pyloric end retains its intestine-like appearance but develops a high muscular potentiality. The embryonic duodenum is rotated about the head of the pancreas and becomes more or less fixed by the loss of some of its posterior peritoneum in the lower portion. The duodenum is U-shaped, with its concavity directed toward the left and upward. Its outlet is within an inch and a half of its pyloric entrance. The large caliber-fixed position and trap-like shape of the duodenum make it an admirable mixing receptacle, and syphonage plays almost as important a part as muscular action in emptying it.

In many animals the entrance to the pyloric end of the stomach is controlled by a true sphincter which does not exist in man, although physiologic contraction graphically marks its situation. The terminal three-fourths of an inch of the pyloric end of the stomach, the so-called "pyloric canal of Jonnesco," may be considered a part of the sphincter apparatus of the pylorus, serving as a passageway only. It is not subjected in the same manner to the traumatism and contact with acid gastric secretions which constitute so potent a factor in the production of ulcer both in the pyloric end of the stomach and the upper duodenum; therefore, primary ulcers in the pylorus and pyloric canal are rare.

Ninety per cent. of gastric ulcers are to be found in the pyloric end, which contains but one-sixth of the gastric mucosa, while the beginning of most duodenal ulcers will be detected at the point of impact where the acid chyme is forcibly ejected through the pylorus against the duodenal wall.

Physiologically the acid chyme in the pyloric end of the stomach stimulates the gastric motor and secretary functions. In the upper duodenum it controls the

pyloric apparatus, and the rate of the gastric outflow is regulated by the rapidity with which this acidity is neutralized by the alkaline, biliary and pancreatic secretions.

Pathologically the acid stomach juices, either because of perverted secretion or through lack of local resistance, or both, become the most important factor in the development of ulcers, and largely confines their ravages to these two embryologically associated structures, the duodenum and the pyloric end of the stomach.

The first notable contribution to the subject of duodenal ulcer and its surgical treatment was the presidential address before the American Surgical Association in 1900 by Dr. Robert F. Weir. The total number of cases reported at that time was small, and nearly all of them were acute perforations into the free peritoneal cavity.

Perforation is comparatively common, but fortunately the contents of the duodenum are relatively sterile and small in amount, which favors plastic protection. In the 272 operations (up to June 1, 1908) perforation was found 66 times: 16 acute, with three deaths; 13 subacute, with abscess, no deaths, and 37 chronic protected, with one death.

Acute perforation of the duodenum is sometimes diagnosticated as perforative appendicitis, and, as remarked by Codman, it is probable that a number of acute perforations are not differentiated even at the operating table, and a careful examination of the appendix in some cases of septic peritonitis from supposed appendiceal perforation would show that its peritoneal surface only was involved and that the lesion was in the duodenum.

Out of 27 cases of acute perforation of the stomach and duodenum in which we have operated, 16 were duodenal. In 3 suture of the opening and gastrojejunostomy was done, in 13 suture without gastrojejunostomy, and of these only one required secondary

gastrojejunostomy. In addition, 12 subacute perforations were walled off with encapsulation of infected material which had escaped from the perforation and caused a secondary abscess to form, such as described by Lund. All but one of the patients with acute and subacute perforations have remained well, the perforation having seemingly put an end to the disease. In this one exception, although the ulcer was healed, a secondary obstruction rendered gastrojejunostomy necessary at a later period.

Acting on this observation, we have four times produced the condition of perforation by cutting out the crater of the ulcer and closing the defect by suture. The results have been good, but sufficient time has not elapsed to know if it will be permanent; but it is a much easier and safer operation than the excision of the entire indurated and cicatricial area about the ulcer which we have heretofore practiced. The extensive operation, however, would be indicated if there was any evidence of malignancy, which, as we have already pointed out, is less liable to take place in ulcer of the duodenum than in ulcer of the stomach.

Chronic protected perforation occurred 37 times. In the chronic form, unlike the acute form, incomplete perforations with adhesions protecting the base of the ulcer seemed to act as an aggravation to the condition, and recurring attacks of local peritonitis were the rule, often producing symptoms resembling those of gallstone disease, for which the manifestations were sometimes mistaken.

A marked peculiarity of duodenal ulcer is the periodicity of the attack, beginning as a rule in early adult life. The subject, usually a male, has an attack of stomach trouble, of which acidity is a prominent feature. This lasts a few days or weeks and is followed by an "almost well" periods of weeks or months. These symptoms recur with increasing frequency, the patient

finding some relief from a restricted diet. In the later stages mechanical obstruction often appears. Hemorrhage occurs in about one-half of the cases.

A differential diagnosis between gastric and duodenal ulcer can usually be made. In duodenal ulcer the pain and tenderness, as a rule, extends from the mid-line to the right; aggravation induced by food comes on several hours after a meal, and the patients suffer from a peculiar "hunger pain" when fasting.

Unlike gastric ulcer, duodenal ulcer rarely undergoes carcinomatous degeneration. We have seen but four apparently primary carcinomas of the duodenum. In two of these the origin was uncertain, and in but one did it seem probable that the cancer had developed on ulcer. In five cases, however, we have known gastric cancer to develop on the edge of a duodenal ulcer which involved the stomach at the pyloric ring.

The surgical treatment of chronic duodenal ulcer will usually consist of gastrojejunostomy, preferably by the "no loop" method.

We have made 311 gastrojejunostomies for ulcer of the stomach and duodenum by this particular method, with a mortality of less than 1 per cent., and but three patients have required a secondary operation on the stomach or duodenum for any cause.

If the ulcer has caused hemorrhages we tie the blood vessels leading into it, and with sutures cover with sound tissue (Fig. 2). Should there appear to be any danger of perforation, the site of the ulcer is covered in the same manner as recommended by Mr. Moynihan, who calls attention to the possibility of secondary perforation.

In four cases we have excised the ulcer with direct union to the stomach. This did not prove a very satisfactory procedure, as in two of them we were compelled to do gastrojejunostomy later. In several of the cases,

however, we were able to excise the ulcer and close by plastic repair after the Finney plan with good results.

In one case an obstructing ulcer of the duodenum an inch and a half below the pylorus so angulated the duodenum on itself that it was comparatively easy to do duodeno-duodenostomy between the first and second portions of the duodenum. Figure 3 is from a drawing of an hour-glass duodenum, the result of ulcer, which was cured by resection with end-to-end union.

In this connection I wish to again call attention to Figure 1. The arrangement of the blood vessels of the duodenum just below the pylorus are such that if the pyloric end of the stomach is pulled upward rather firmly, as one must often do to obtain a view of the parts, an anemic spot will appear in the duodenum just below the pyloric ring. This appearance is at times very striking and may closely resemble an ulcer. On one or two occasions we were obliged to incise the duodenum at this point before we could be certain that no ulcer existed. The tissues apparently involved are normal to the feel and do not have the milky appearance of the peritoneum of true ulcer, and there are neither adhesions nor other abnormality. If the traction is taken off, it will be seen at once that no ulcer exists.

There has been much discussion as to the curative value of operation for ulcer. From our own experience we can say that the surgical treatment has been most satisfactory. The small esteem in which surgery of the stomach and duodenum is held by many professional men, and the bad results reported, have been largely due to mistakes in diagnosis and unnecessary operations performed where no ulcer existed.

We have, as far as possible, traced our patients with duodenal ulcers operated on in 1906-7. These two years were chosen because this choice eliminated some of the early operations in which the diagnosis was doubtful and the technic imperfect, and it prevented the inclusion

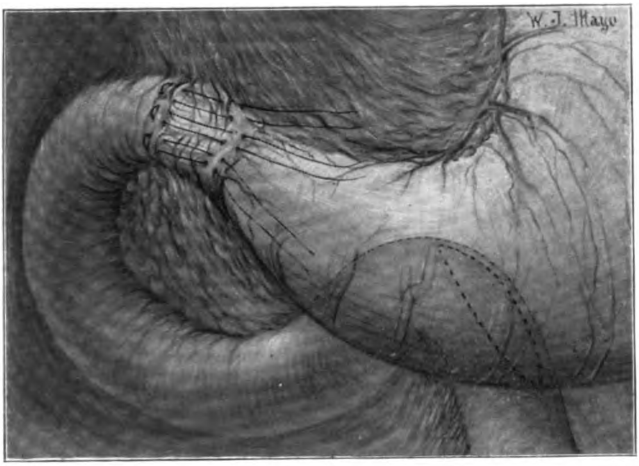

Fig. 2.—Ulcer of the duodenum with sutures in place for the purpose of enfolding. Posterior no-loop gastroenterostomy indicated.

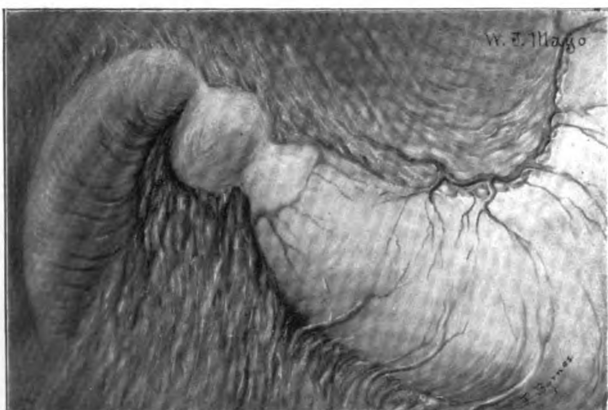

Fig. 3.—Hour-glass duodenum which was treated by excision with end-to-end union between the duodenum and the stomach.

of the recent cases that the shortness of time since operation would render valueless to statistics from the standpoint of cure.

Of the 119 patients operated on in 1906-7, we have information of 106. Of these 87, or 82 per cent., were cured; 10, or 9.5 per cent., improved; and 6, or 5.7 per cent., unimproved, making cured and improved 91.5 per cent. The operative mortality in the whole number of cases was 2.8 per cent.

THE DIAGNOSIS AT OPERATION BETWEEN CHRONIC ULCER AND CANCER OF THE STOMACH.

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BOSTON.

In my experience with gastric surgery, although not extensive, I have been confronted with difficulty in deciding in certain cases between the presence of benign and malignant disease, a decision so important and at the same time so difficult that the subject seemed to me worthy of consideration.

The past decade has been one of great activity in the surgery of the stomach. The work has been prosecuted with marked interest and zeal, and, on the whole, with commendable sanity and judgment. Nevertheless, it can not be denied that, as has been inevitable in any new department of surgical endeavor, we have had to feel our way by constant experiment and modification. Mistaken methods have been tried and found wanting; excellent procedures have been misapplied, and it is only recently that we have reached firm ground in such important points as the best method of gastroenterostomy and the technic of resection in cancer. There can be no doubt in the minds of those who have followed the work in this field closely that in the early days many operations were done which in the riper experience of the present day would not be deemed good judgment, that gastroenterostomy was done with poor results in such conditions as neurasthenia accompanying gastroptosis, in hemorrhage from medical (acute) ulcer, and other

conditions, which experience has taught us to-day, are best not operated on. Medical or acute ulcer, with or without hemorrhage, ptosis attended by neurasthenia, and all non-obstructive lesions of the stomach, except chronic ulcer and cancer, have been practically eliminated from the surgery of that organ. Hour-glass stomach due to contraction of the scar of a chronic ulcer, or to adhesions, is, of course, classed among the obstructive lesions.

British and American surgeons have contributed in no small degree to the rapid advancement of our knowledge of this subject, and among those who by example and precept have been foremost in this field I need only mention such names as those of Robson and Moynihan[1] in England, and the Mayos, Rodman, Finney[2] and Munro[3] in this country.

In regard to cancer of the stomach, there can be no doubt that in operable cases, which means those cases in which the growth with a fair margin of stomach and the involved glands can be removed, the only treatment which gives any promise of relief is in excision, and from my own experience, though small, I am glad to be able to corroborate the statement of Mayo that cancer of the stomach is as amenable to treatment as is cancer of the breast. It is not, however, with the plain unmistakable cancers of the stomach that I wish to deal in this paper, but with those cases—and they are not rare—in which even after all preliminary methods of diagnosis have been exhausted and with the abdomen opened and the ulcer under the eye and touch, we can not distinguish between a chronic ulcer and a cancer. If the treatment justified were in both conditions the same, the fact could make no difference. In fact, no less an authority than

1. Moynihan, B. G. A.: A Review of 59 Cases of Cancer of the Stomach Treated by Operation, Tr. Clin. Soc. Lond., 1906, xxxix, 84-95.

2. Finney, J. M. T., and Friedenwald, I.: Unusual Case of Ulcer of the Stomach, Boston Med. and Surg. Jour., 1907, clvii, 393-395.

3. End Results in Benign Lesions of the Stomach Surgically Treated, Am. Surg., 1907, xiv, 818-826.

Finney makes the statement that in all operable chronic ulcers gastrectomy should be performed, owing to the fact that they are indistinguishable from cancers, and gastrectomy rather than local excision is the best treatment for chronic ulcer.[4]

Perhaps we may come to accede to this statement, in so far as it is applied to nonadherent ulcers so situated as to be easily excised, such, for instance, as saddle ulcers on the lesser curvature; but there is another class of cases, in chronic ulcers on the posterior surface and at the pylorus and extending into the duodenum, when the determination of malignancy is of greater importance. In fact, it seems to me that these cases fall into two distinct classes, namely, (a) saddle ulcers of the lesser curvature; and (b) ulcers at the pylorus extending onto or from the duodenum and adherent to liver or pancreas.

Cases of the second class are not inoperable, by which Dr. Finney evidently means incapable of excision, but their excision is difficult and attended by a risk which we should be willing to accept in cases of malignant disease but not in the treatment of simple ulcer, especially when we consider the many reported cases of simple ulcers in this situation cured by gastroenterostomy. Robson goes so far as to say that in adherent ulcers at the pylorus, even when they are greatly thickened and there is a suspicion of malignancy, gastroenterostomy should be performed, and he refers to a number of cases in his experience in which this procedure has proved curative. His experience is confirmed by many others.

Anatomic as well as clinical evidence of the cure of these patients is not wanting, from second laparotomies and occasionally from autopsy, as in Hoffmann's patient who died of strychnin poisoning two years after a gastro-

4. A parallel example of the induration due to chronic subperitoneal inflammation simulating malignancy may be found in those tumors of the cecum which by their stony hardness and appearance so simulate carcinomata, and which disappear so quickly after an inflamed appendix has been removed from among their adherent coils.

enterostomy for indurated ulcer at the pylorus, in which the autopsy showed a smooth scar, the ulcer having completely healed.

Hoffmann,[5] however, while presenting the well-known advantages of gastroenterostomy over excision in most cases, states that if appearances at operation strongly suggest malignancy, resection should be done. He applies this statement to indurated ulcers, both at the pylorus and on the lesser curvature. He reports 52 cases of benign disease of the stomach from the Graz clinic.

Von Eiselsberg,[6] speaking of stenosis of the pylorus, advises gastroenterostomy, but admits that in many cases it is difficult to decide whether an ulcer or a carcinoma is present, and states that under these circumstances, if the patient is strong enough, excision should be done. He reports in this paper thirty-nine gastroenterostomies for benign pyloric stenosis with one death, and eleven resections for benign disease with two deaths.

Hochenegg (Schulz[7]) performed gastroenterostomy in two cases in case of doubt, one because the patient was in poor condition, the other because of adhesions. Both patients did well at first, but died within twelve months after operation, and in one an autopsy showed cancer developing on an ulcer base.

On two occasions, however, I have subjected patients with chronic ulcers at the pylorus and extending onto the duodenum to a difficult and tedious excision, only to find that the ulcers were non-malignant. Although both patients recovered, one died four months later from contraction of the new stoma, which, owing to the length and difficulty of the operation, had been made by a Murphy button; this length of the operation was partly due

5. Haben wir in Zukunft günstigere Resultate von der chirurgischen Behandlung des Magencarcinomes zu erwarten, und besteht ein Zusammenhang zwischen klinischer Krankheitsdauer, und Radikal operabilität? Mitt. a. d. Grenzgeb. d. Med. u. Chir., Gedenkband, v. Mikulicz, 1907, pp. 879-892.

6. Die chirurgische Therapie des Magenulcus, Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1906, xvi, 1-18.

7. Zur Statistik der Gastroenterostomien bei benignen Magenerkrankungen, Deutsch. Ztschr. f. Chir., 1906, lxxxviii, 494-552.

to the fact that the common duct was accidentally divided and had to be reimplanted in the duodenum. It is in this class of cases that laboratory studies are of greatest importance and therefore should always be made before operation. In these cases of adherent ulcer, in which the question of excision is a delicate one, the presence and amount of free hydrochloric acid may aid in the decision, and so far in my cases has proved a good guide.

In regard to cases of the first class, the saddle ulcers of the lesser curvature, my experience has been different.

A gastroenterostomy for a supposedly benign saddle ulcer of the lesser curvature failed to cure one of my patients, who gradually failed and died in a few months, probably from extension of a gastric cancer; and an excision in a similar case of a supposedly benign ulcer, which was subjected to an immediate microscopic examination, showed the presence of cancer and enabled a more extensive excision to be performed at once, with the gratifying recovery of the patient. An excision of a saddle ulcer of the lesser curvature with a wide margin of stomach with enlarged glands thought to be a cancer and therefore dealt with radically, resulted also favorably to the patient. Another patient, in the hands of a colleague, who came under my observation, and on whom a gastroenterostomy was performed for a supposedly benign ulcer of the lesser curvature, had a recurrence of symptoms a year or two later, and a second laparotomy disclosed a cancerous peritonitis.

Recently a patient on whom I performed a gastroenterostomy for a chronic saddle ulcer of the lesser curvature three years ago, excision being impracticable on account of adhesions to the liver, came to autopsy, and examination showed a cancer. In this case, undoubtedly, a cancer developed on an ulcer base, a condition to the frequency of which attention has been so often called in recent years by Mayo, Graham and others, and one which is a further argument for excision whenever

possible. In these cases the presence or absence of hydrochloric acid has been an unsafe guide, and I believe these ulcers should all be excised, regardless of laboratory findings.

It is useless further to multiply examples which might demonstrate our inability to distinguish cancer from chronic ulcer. The practical questions for us are: First, how near can we come to a diagnosis and what aids can we summon before and during operation? Second, the aids failing us, how are we to proceed under the variable and deceptive conditions met with during operations? Partly on one's own experience, guided, of course, by the written and spoken advice of others of perhaps greater experience than one's self, but after all chiefly by one's own personal opinion, must the question in each case be settled. An attempt to formulate the principles which should guide us may well be prefaced by a brief statement of the clinical pathology of the disease.

With the superficial medical ulcer which involves the mucous membrane only, frequently bleeds and often is the cause of pain, but is curable under judicious rest and feeding, we have not to deal. Whether such an ulcer heals under medical treatment or becomes chronic, i. e., surgical, depends on whether sufficient rest can be given the ulcer without starving the patient and leaving the general nutrition so poor that the tissues can not heal. I may remark in passing that now that the long periods of rectal alimentation (essentially absolute starvation) in the treatment of this disease have been given up, a practice which often exhausted the patient to a point where the tissues were so devitalized that healing could hardly be expected, and feeding almost from the first has been adopted, we shall probably find fewer chronic or relapsing ulcers to operate on. Food which gives the maximum of nutrition with the minimum of work to the stomach we have learned may be given almost from the first, and with careful diet and supervision after the acute symptoms have disappeared and the patient dis-

charged from the hospital, I believe we shall have less chronic ulcers develop. This is only one of the many beneficial results from the success in prescribing dietetic regimens which medical men are attaining, as the result of special attention and study, and which have already given such remarkable results in obesity, diabetes, etc.

To return, however, to the subject, the relapsing, chronic, or surgical ulcer invades the muscular layer of the stomach until a definite patch of varying size becomes converted into scar tissue, white, of stony hardness, and of varying thickness, according to the time it has existed. Such a scar has elevated indurated edges where the infiltrated, ulcerated mucous membrane surrounds it, the edges may be excavated,, so that any one may be defied to tell by touch or inspection whether they are cancerous or not, and glands may be involved and also indurated, so as still further to simulate malignancy.

Of the two large saddle ulcers above referred to, which I excised and which looked almost exactly alike, one being simple and the other carcinomatous, the cancerous ulcer was the least indurated and least malignant looking of the two. Excision of a portion of the ulcer for pathologic examination is undesirable, because it complicates the technic, because of the time wasted in waiting for a report, and because of the danger in case of malignancy, of infecting the open wound with cancer cells.

Excision of the entire ulcer and immediate examination of the specimen may help, and, in fact, in my second case the report of cancer enabled a more extensive resection, with the happiest results. However, even this method may fail, for the pathologist may have to cut and examine several portions of ulcer before he arrives at a malignant part and the delay may be too great.

In doubtful cases two facts may help us: one, that cancer rarely starts from the duodenum, so that if the duodenum seems primarily involved the induration

probably is benign; and second, that benign ulcer perforates early as compared with cancer. So that subacute perforation with adhesions to the liver or pancreas in a case early enough to be a doubtful one points toward benign disease. The very induration attending subacute perforation may be the reason for the simulation of malignancy, or, to put it differently, the very conditions which render excision difficult may point to its being unnecessary.

In the second group of cases mentioned above, in which I excised two moderately adherent ulcers of the pylorus and first part of the duodenum, the situation was as follows: The clinical evidence and laboratory tests, hyperacidity, presence of free hydrochloric acid, etc., pointed in both cases to chronic ulcer. The induration and thickening of the pylorus and first part of the duodenum was of such a character as to suggest malignancy. In one I had previously (four weeks before) performed a gastroenterostomy without relief and the growth had increased in size. I felt that both lesions were probably malignant and performed resections, made difficult and dangerous by pancreatic adhesions, only to have both reported benign. In the first case I should have allowed the facts that the clinical and laboratory tests pointed to a benign condition and that carcinoma of the stomach rarely arises from the duodenum influence me; and in the second case the same factors, plus the knowledge that the inefficiency of the gastroenterostomy was in part, because the lumen was too small or, in other words, a technical error. I performed Rodman's ideal operation, excision of the ulcer area, but in the presence of adhesions which made excision rather dangerous, and in the face of the fact that the very ulcers which are most amenable to healing under gastroenterostomy are those of the pylorus. I think under ordinary circumstances a gastroenterostomy is to be preferred in such situations.

I have performed seventeen gastroenterostomies for indurated thickened ulcer at the pylorus, some of which were bleeding freely at the time of operation, with one death and with uniformly good results in sixteen cases; and also on three ulcers at the lesser curvature adherent to the liver (perforated chronic ulcers), with permanent cure.

Of seven cancers of the stomach in which I have performed partial gastrectomy, two patients died as the result of the operation, one of the deaths occurring many years ago before I was acquainted with modern technic, and the other in a case in which an excision was undertaken in the presence of too great glandular involvement, after gastrectomy and enucleation of large masses of glands around the common duct and pylorus, accompanied by considerable hemorrhage. All the other patients were benefited by the operation. The most extensive lesion was in an old man of 68, in whom two-thirds of the stomach was removed; he gained twenty pounds and lived in comfort for a year. The least extensive lesion was a cancer of the lesser curvature; the patient was only slightly relieved and died in seven months. One patient is alive and perfectly well two years after the operation and has gained forty pounds; one is alive and perfectly well eight months after the operation and has gained forty-six pounds. My colleague, Dr. Nichols, has a patient in whom two-thirds of the stomach was removed, and who is well two years later.

If I may add my three cases of partial gastrectomy for benign disease, we have nine cases with two deaths, and considering the reasons for those two deaths I feel that the operative risks are not great. If I can keep from taking desperate chances in inoperable cases I feel that my mortality rate ought to be good.

The comfort of the convalescence from the gastrectomy cases, both benign and malignant, has been remarkable. Both the Billroth No. 11 and the Kocher

method have been followed, but the finer points of technic have been, in the main, those advocated by Mayo[8] in 1906, which is, I think, a classic and for which we owe him a very great debt.

Such success as we have had in cancer cases emphasizes the importance of making an accurate decision in early cases, which are the very ones in which we can hope for most and perhaps may justify the writing of this paper. I am aware that I have suggested no certain method which will accurately decide for us in doubtful cases. No harm can be done by an attempt to set forth the principles which should guide us in making these very important decisions, and for this reason, and in the hope that the discussion may throw more light on the situation than I have done, I am emboldened to present this paper.

CONCLUSIONS.

In certain cases of indurated ulcer of the stomach the diagnosis between benign and malignant disease may be impossible, even with the abdomen opened. These are the early cases, in which the diagnosis of early cancer is important, as enabling thorough removal.

These cases, broadly speaking, fall into two classes:

1. Indurated ulcers (usually of the lesser curvature), which are movable and free and may be benign or malignant. Here, even if the tumor is benign, gastroenterostomy is often unavailing, and partial gastrectomy should be performed. Excision here is easy and safe.

2. Indurated ulcers of the pylorus often extending from the duodenum and adherent to the pancreas or left lobe of the liver. These are usually benign; excision is difficult and gastroenterostomy is safe and should usually be performed rather than excision.

In Class 1 excision should be done regardless of laboratory findings. In Class 2 the laboratory findings are important and usually reliable.

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8. Technic of Gastrojejunostomy, Ann. of Surg., April, 1906.

The responsibility of leaving a tumor which may be malignant is so great, however, that all diagnostic aids should be invoked, and in case of doubt excision, though at some risk, may be performed. The surgeon must decide in each case whether the risk lies in performing excision or leaving a tumor which may be malignant.

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DISCUSSION.

ON PAPERS OF DRS. MAYO AND LUND.

DR. ALEXANDER HUGH FERGUSON, Chicago: I think there is no prominent surgeon in America to-day who would even dream of asserting that he never errs in making a diagnosis between carcinoma and chronic ulcer of the stomach. There are certain things, however, that we see and feel at the time of operation, irrespective of the history of the case before the patient comes to the operating table, which lead the surgeon to lean on one side or the other in his diagnosis of the border-line cases. For instance, one opens the abdomen and finds at once a large amount of straw colored fluid coming through the incision. It evidently is a case of neglected carcinoma, a very far advanced case. We do not very often open up the abdomen in such cases to-day, but we have in the past. If we see extensive adhesions and if we pass in the hand and feel them without feeling a tumor, the diagnosis is rather of inflammation that has disseminated itself and caused these adhesions to form. If, however, we find thick, continuous, friable adhesions between one viscus and another, between the stomach and the transverse bowel, between the stomach and the parietes or liver, then we may be sure that points to carcinoma. This, too, would be a very late and inoperable case. Often in the early case in which the tumor mass is movable we can not make a diagnosis even when the ulcer is seen and felt, for malignancy may be just beginning.

There are certain ways, however, in which we may proceed to determine what we have in hand, and that is to pass the entire hand into the abdomen, exploring the lymphatics and organs. The anterior surface of the stomach can be palpated with one hand, but when the posterior surface is to be palpated both hands must be used. By careful palpation we may be able to determine a tumor mass where we did not suspect it, located at some place in the stomach wall, that gave but meager symptoms or signs of such an advanced condition. When, however, it is in the pylorus, obstructive symptoms and signs tell whether it is carcinomatous or due to ulceration in a much earlier stage.

What does all this teach? It teaches that patients who suffer with gastric symptoms during the carcinomatous age

ought to be explored early, because only by such early explorations can the pathologic condition be removed, and it is only of temporary use to do a gastroenterostomy.

DR. VAN BUREN KNOTT, Sioux City, Iowa: I take it that the differential diagnosis is not so important in these extremely late cases referred to by Dr. Ferguson as it is in the earlier cases, in which there is a large infiltrated area at or near the pyloric end of the stomach. It is well known that the preoperative diagnosis between carcinoma and ulcer of the stomach is extremely difficult; in fact, it is one which we very frequently fail to make. Men of experience are equally well acquainted with the fact that the diagnosis at operation, with the abdomen open, is, in many instances, practically impossible. Finney last month reported two cases before the American Surgical Association, in which at operation, with the abdomen open, he was unable to decide whether he was dealing with a carcinoma or an ulcer at the pylorus. Frozen sections also often fail to determine whether the growth is benign or malignant. This is a striking instance of making a differential diagnosis under great difficulties. If it be true, as Dr. Mayo told us, in accordance with the statistics of many observers, that implantation of carcinoma on ulcer is found to occur in over half of the cases of ulcer of the stomach, it would seem that the differential diagnosis at operation between large infiltrated inflammatory growths at the pylorus, between benign and malignant growths so situated, is not important, because in cases amenable to radical operation we should be conserving the best interests of the patient by doing a pylorectomy or partial gastrectomy and cutting out the growth, thus doing away with the possibility of implantation of carcinoma or ulcer or a recurrence of the growth and troublesome symptoms.

The statistics of pylorectomy to-day are very much worse than those of gastroenterostomy. Every one has done a pylorectomy in cases in which a growth suspected of malignancy was removed and found to be benign, and every one has also had the experience of doing a Rodman operation for ulcer and finding that the mass removed was a tumor of a malignant character.

DR. PARKER SYMS, New York: Gastric and duodenal ulcers are so closely allied clinically and surgically that they may practically be considered to be identical. The pyloric part of the stomach is a common seat of ulcer, and the upper one and a half inch of the duodenum is the common and usual seat of duodenal ulcer. Of course, in this discussion we may leave out of consideration the superficial acute ulcers common in young women, and which may be treated properly by dietetic and hygienic means. We are considering the chronic, deeply-situated ulcers, the indurated ones that do not tend to get

well; it is these ulcers that present the greatest immediate and remote dangers.

Every case of gastric and duodenal ulcer should be recognized and cured. Attempts to effect a cure by hygienic and dietetic means should be limited to a brief space of time, and in all cases in which symptoms persist and a recurrence takes place operative procedures should be resorted to because the results will be much better than if a so-called expectant or conservative treatment is employed, and because the dangers of an uncured ulcer in this region are too grave to be neglected. Cancer of the stomach is a disease which can hardly be cured when it can not be recognized without opening the abdomen; therefore, our only means of curing this disease is to operate at a time so early that the diagnosis could not be made by the usual method.

Other dangers of duodenal ulcer are perforation and hemorrhage. There is no question that the vast majority of cases of ulcer of the duodenum and stomach may be cured by gastroenterostomy, and the preferable method of performing the operation is the one described by Dr. Mayo. We must not, however, neglect the fact that the end results are yet to be determined, and the argument put forth by Rodman calling for pylorectomy and removal of the tissue which may later become cancerous is too strong to be neglected.

Dr. N. B. Leggett, New York: I shall confine my discussion to the question of the function of the stomach in the presence of an open pylorus. The details which I am going to present are elaborated from the result of a series of experiments carried on at the Surgical Research Laboratory of Columbia University during the past winter. A gastroenterostomy was done on seventeen dogs, and by means of a simple probang devised by the laboratory student assistant, Mr. A. G. Sullivan, a "B. B." shot, after being attached to a strong linen thread, was introduced into the stomach of each. The probang consisted of a heavy piece of wire strong enough to reach from mouth to stomach and twisted at one end. The other end was cast into a handle of lead. In use the string was threaded through the eye and the attached shot is brought up against the metal. The dog was then anesthetized, its mouth held widely extended and its neck straight. The probang and shot thus passed readily through the cardia. At this moment the handle, which was purposely made heavy and of lead, was sharply struck with a heavy metal instrument. The blow was transmitted to the shot, which flew off into the stomach, carrying the string with it. The probang was then withdrawn, a needle threaded to the string, passed through a fold in the base of the pharynx and there knotted. Two days later the dogs were killed with ether. Clamps were placed on the cardia, the pylorus and the intestine aboral to the stoma to prevent the string from slipping during the removal of the specimen. After hardening, the specimens were dissected, so

as to show the position of the string as indicating the path taken by the bullet, and mounted.

There are obviously four ways in which the shot may travel, namely: first, through the pylorus and on down into the intestine past the stoma; second, through the pylorus and into the stomach by way of the stoma, namely, a direct cycle; third, through the stoma and into the intestine, the supposed normal course; fourth, through the stoma and back into the stomach, a retrograde cycle. All the stomata were made on the anterior aspect of the stomach. Of seventeen specimens studied, twelve were found to have the stoma within an average of 5 c.c.m. of the pylorus, while in five the stoma was located at the most dependent portion of the stomach. On account of the variation in size of the animals operated on, the actual distance from stoma to pylorus would not create a correct impression. Of the twelve stomata placed near the pylorus, in five, or 41 per cent., the linen thread passed through the stoma. In seven, or 59 per cent., it passed through the pylorus; in one of these, two strings were fed, one passing through the pylorus and the other through the stoma. The string passing through the stoma made two complete cycles. In two cases in which the string passed from the stomach through the pylorus and again into the stomach through the stomach, the cycle was complete, and in one case a string making an exit from the stomach via the pylorus made three complete cycles. In this case the stomach was greatly dilated. Of the five specimens in which the stoma was located at the most dependent point of the stomach, the position of seven strings was to be studied, because in one case three strings were fed. In this case two strings were found to have passed through the stoma, one making a complete retrograde cycle twice. The third string had passed through the pylorus, making one direct cycle. In the five cases, four strings were found to have passed from the stomach by way of the pylorus and three by way of the stoma.

A point of interest, because it suggested a possibility of obstruction from spur formation at the point of the stoma, was the fact that when the cycle was direct, namely, through the pylorus and back again into the stomach through the stoma, the stomach was found to be uniformly dilated. In an anterior gastroenterostomy the stoma is used almost as frequently if placed at the dependent point of stomach as if near to the pylorus. Roughly speaking, the unobstructed pylorus is used to transmit one-half of the shot swallowed, the remaining half passing through the stoma. Whether this proportion holds true for the semi-solid chyme can probably be determined by feeding string without shot.

Dr. F. B. Lund, Boston: The problem of distinguishing between an induration due to chronic ulcer and that due to car-

cinoma is to determine between actual tissue growth and deposit by inflammation, as in appendicitis where the appendix, buried under an inflamed cecum, has given rise to appearances of malignancy and where recovery occurs after removal of the appendix. I have seen such cases of appendicitis where the cecum was excised on account of the simulation of malignancy. Dr. Mayo's statement that many pyloric ulcers are really duodenal ulcers is a help in the decision how to deal with these cases because duodenal ulcers rarely become malignant, while resection of movable ulcers anywhere in the stomach is simple and safe if one follows the technic he so well demonstrated for cancer of the stomach.

In perforating ulcers of the duodenum the tenderness is often over the appendix and not over the site of the perforating ulcer. I attribute it to the fact that the greatest tenderness is at the edge of the inflammation. Cases in which a perforating ulcer of the duodenum was mistaken for appendicitis are the cases in which the starvation treatment never produces a cure, so that the operator who waits for the case to quiet down before operating willl be disappointed.

Dr. William J. Mayo, Rochester, Minn.: There are a few points to which I wish to call attention. First, duodenal ulcer is more frequent than gastric ulcer; second, although we are told in the text-books of the past that 60 per cent. of gastric and duodenal ulcers occur in women, that the contrary is true; third, if one does a gastroenterostomy for ulcer without proving at the operating table that the ulcer actually exists the operation will probably do the patient harm.

I think that the surgical cure of duodenal and gastric ulcers is certain in at least 80 per cent. of cases, and in 10 per cent. more the patient will be so much benefited as to be well satisfied with the result. Finally, I plead for earlier recognition of cancer of the stomach, and I would emphasize again the fact that a very considerable percentage of cases of cancer of the stomach begin in ulcer. There should be two classes of patients turned over to the surgeon promptly—those with tumor of the stomach and those with obstruction. Why is it that in the great hospitals, cases of cancer of the stomach are found in the medical wards? Can one do any more medicinally in this disease than can be done in cancer of the breast, lip or uterus? A suspicion of cancer makes the case a surgical not a medical one, and the patient should be sent to the surgical side at once.

Again, if a tumor is present, what difference does it make whether that tumor is due to inflammation surrounding a thickened chronic ulcer that is liable to undergo carcinomatous degeneration, or whether cancer actually exists at this time? You will be surprised in some instances at the length of time patients are worked over for a diagnosis with a palpable

tumor that, perhaps, they have discovered themselves. Let me say, too, that the moment you make a diganosis of tumor, no matter what its nature may be, you must consider the case a surgical one, and the surgeon should be called in consultation. I have yet to see the case of mechanical obstruction that can be cured by medical means when it is caused by chronic ulcer. Chronic ulcer producing obstruction can be carried along in various ways, but it can not be cured. When mechanical obstruction is present it is easy to tell by means of the stomach tube. Give the patient raisin cake or some raisins at bedtime. Pass the stomach tube in the morning and see if you can find the skins.

INTESTINAL ANASTOMOSIS; PRESENTATION OF A NEW, SIMPLE AND ASEPTIC METHOD.

FRANK B. WALKER, M.D.
DETROIT.

Ever since the memorable pioneer work of the late Dr. Nicholas Senn, intestinal surgery has been an attractive and fruitful field. During this brief period there have been proposed many ingenious methods of anastomosis and devices for their performance. Some of them have already become obsolete, while others are gradually being superseded by simpler means. The methods in vogue are serviceable in skilled hands, but are complicated and liable to sepsis or are incomplete. None has been stamped with unqualified approval. All except the McGraw elastic ligature are done on a wide-open gut and are essentially septic operations. The ligature method—the simplest and cleanest of all—does not complete the anastomosis for three or more days and is, therefore, incompetent for those cases in which another communication does not exist.

With the development of definite sutural methods there has arisen a disposition to discard contrivances as unnecessary if not also complicated. The Connell suture—the best representative of them—I have used in preference to all other methods, both sutural and instrumental, and taught to about six hundred graduate students. Although I have been able to adapt it readily to any form of anastomosis I observed that it was difficult for many to learn and for all to remember

unless they were in constant practice. Except for the danger of sepsis from the open gut and the somewhat intricate suturing of the last part and tying of the last knot, I should regard it as ideal.

Ideal or physiologic anastomosis has been little sought. The possibility of doing the operation with safety and the advantage of this or that special technic have been reported and discussed frequently, but seldom have the principles of intestinal anastomosis been given adequate consideration. In my opinion, too much has been taken for granted. For instance, the conception of anastomosis not uncommonly held is the making of a communication merely between two attached viscera. It is true that result is accomplished, but that alone will not always fulfill the requirements. Intestinal anastomosis is purely a drainage operation, but to be of any value it must first of all be needed and in the second place unobstructed drainage must be obtained.

The conclusion jumped at, that gastrojejunostomy would cure atonic dilatation and prolapse of the stomach, because it would drain, and gastric or duodenal ulcer, because it would rest those parts, applied only to the result and not to the cause of disease, and it is, therefore, questionable whether gastroenterostomy be a curative or a palliative measure. This doubt is strengthened by reason of the facts that not only have the symptoms attendant on dilatation returned and ulcers reappeared lower down after apparent temporary relief, but it has been found in some cases that the anastomotic openings had healed shut. In other words, intestinal anastomosis, although inapplicable in some cases, had been employed as a makeshift instead of other more rational modes of treatment.

From the viewpoints of anatomy and physiology, the normal outlet of the stomach is by way of the pylorus. The stomach contents are propelled not by gravity, but by an inherent mechanism. If drainage be interfered with by some benign abnormality at or near the pylorus,

the adoption of Nicoll's or Finney's or other possible pyloroplasty in preference to gastroenterostomy would conserve the normal mechanism of drainage and give promise of permanent relief. If, however, that passageway be permanently barred and another exit must be provided, gravity would come into play and indicate that the outlet should be situated, if possible, in the lowest convexity of the stomach and, on account of the to-and-fro movement, on the posterior rather than on the anterior surface. The exact point on the stomach longitudinally will depend somewhat on the case. It should be remembered, however, that, notwithstanding the change in shape and position of the organ in the empty and full conditions, the lowest convexity remains near the junction of the middle and right thirds of the greater curvature.

In cases in which anastomosis is performed without resection, it is essential that the communication between the afferent and efferent viscera be direct, and, therefore, that there be no kinking of the distal bowel either at the opening or lower down. Violation of this rule is doubtless responsible for the occurrence of the so-called vicious circle.

In the performance of posterior gastrojejunostomy it is a wise precaution to attach the jejunum firmly to the edges of the opening made in the transverse mesocolon. Failure to do so has been followed by a hernia into the lesser peritoneal cavity and intestinal obstruction.

If the intestine be resected and lateral anastomosis be performed, the stumps should be reasonably short and so attached, each to the other communicating bowel, as to preclude their intussusception. I have observed a long loose stump telescoped through itself into the intestine so far as to make a valvular closure of the anastomotic opening.

Besides promoting free drainage, the ideal method must be safe from sepsis and hemorrhage, simple of

understanding and performance, complete in itself and applicable to all forms of anastomosis.

Sepsis is the most important factor to be contended with in intestinal anastomosis. The introduction of it from without can be controlled in this as well as in any other abdominal operation, but the possibility of infection from the open gut and of postoperative leakage is a constant menace. The danger from these sources can be minimized during the operation by walling off all the other structures with abundant sterile pads placed under and around the parts to be handled. Preoperative stomach washing, milking the intestine and the use of tapes and clamps to hold back the visceral contents serve their purposes, but an open bowel is unavoidable in carrying out any of the methods in vogue, except the elastic ligature, and is a serious defect.

Postoperative leakage is usually due to the following three conditions: (1) imperfect serous apposition at the mesenteric space, (2) sutures too tightly drawn, (3) knotting a through suture on the serous surface.

Serous apposition of the viscera produces valvular approximation of the edges and effectually prevents the escape of bowel contents. This procedure has been adopted in all the methods that have proved successful. In end-to-end anastomosis especial care must be used to invert the mesentery with the intestine at the mesenteric space.

A continuous through mattress suture is preferable to the interrupted form, because it prevents overdistention of the bowel and separation of the edges during the period of healing, and it is more certain than the Lembert suture to close the cut ends of bleeding vessels and to control hemorrhage. It may be introduced and tied from the inside (Gregory Connell) or from the outside (Hayward Cushing). In simplicity and cleanliness the latter excels. A suture that is to be tied on the outer surface, however, should not be carried deeper than the submucous layer on account of the tendency to capillary

action and seeping. No suture should be tied or drawn more tightly than is necessary to secure serous apposition. Otherwise the swelling of the tissues following operation may result in necrosis.

From a theoretical viewpoint, catgut would seem to be ideal suture material, but experience has taught that it softens and separates in the intestinal tissues too quickly to be reliable. Fine twisted silk and linen are safe and answer every purpose.

Almost any method becomes easy through practice, but no method will win universal favor that involves complicated technic or instruments or numerous assistants. A generally acceptable method must also be surgically complete without the mediation of an uncertain hidden contrivance and must be adaptable in any emergency requiring anastomosis.

The method which I present here is not presumed to be a substitute for ignorance of surgical principles or carelessness in their practice, but it can be carried out by one pair of hands with scissors, needle and thread, and combines the advantages of other procedures without their defects. It is based on the closure of the gut during the operation by means of a removable purse-string suture, on serous apposition by a continuous through mattress suture inserted from the outside of the gut, and on the withdrawal of the purse-string suture after the suturing is completed, leaving an open lumen. The technic is shown in Figure 1, and is as follows:

For resection of intestine and mesentery as at R (Fig. 1), and end-to-end anastomosis, place ligatures (L) on healthy bowel proximally and distally beyond the part to be removed. Insert purse-string sutures (P. S.) about bowel one-half inch proximally and distally from ligatures (L) and tie with slip-knot (K), made by drawing only a part of one end of purse-string suture through knot. Ligate mesenteric vessels. With scissors

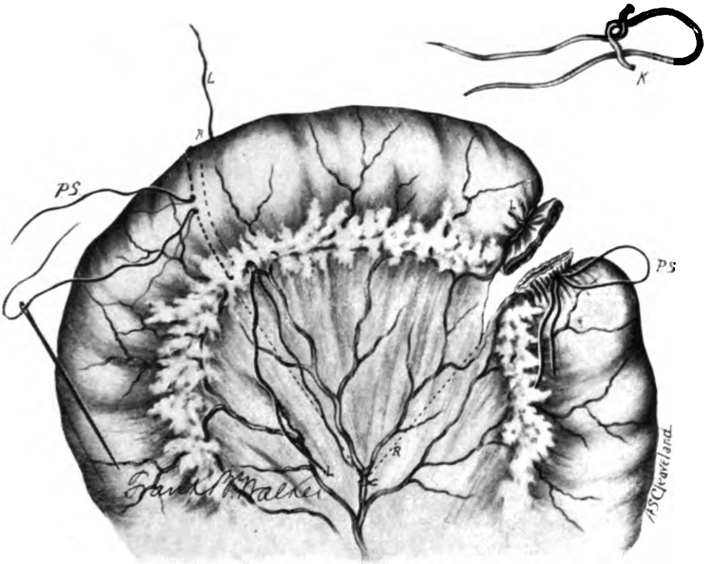


Fig. 1.—L, ligature; PS, purse-string suture; K, slip-knot. The left side of Fig. 1 represents purse-string suture and ligature placed and ready for tying; the right side represents them tied and the gut cut across. In the upper right corner the slip knot is represented on a large scale.

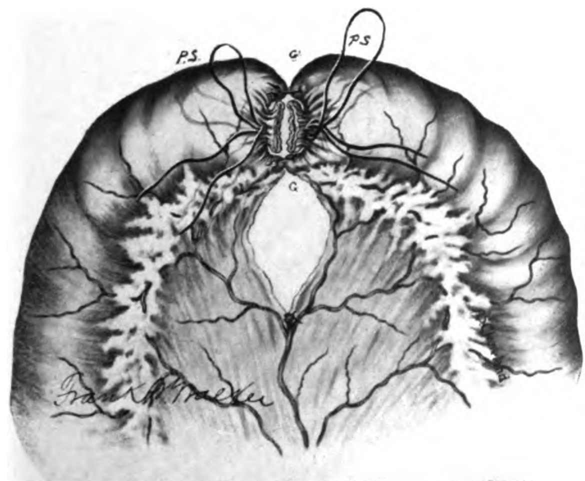


Fig. 2.—This represents the stumps closed by purse string sutures tied with slip knots and held together by two guy mattress sutures (G).

cut across intestine close to purse-strings and divide mesentery as on dotted lines.

Bring the stumps of resected intestine together so that they shall correspond at mesenteric borders (Fig. 2). Place two or three guy mattress sutures (G) about one-eighth inch above purse-string sutures (P. S.) to hold the stumps temporarily in proper relation.

Begin continuous mattress suture (Fig. 3, M) at any point, except at mesenteric border, and with it encircle the bowel about one-quarter inch above purse-string sutures, passing from side to side six or seven times to the linear inch. The anastomotic suture should include the submucosa and may include the mucosa also, as a through suture does, except in that part of it which contains a knot. Extra care is necessary in placing the sutures evenly and in inverting the mesentery at mesenteric borders. The loops and ends of purse-strings project between the passes of the encircling suture until withdrawn. After the encircling suture has been placed around the bowel, drawn sufficiently taut and tied, the purse-strings are untied and withdrawn by pulling gently on their loose ends. The gap in the resected mesentery is closed by sutures or ligatures.

Theoretically, end-to-end anastomosis would seem to be more nearly ideal than the lateral form. It provides a more direct communication and conserves the function of the muscular mechanism of the intestine. It is impossible of adoption, however, in certain pyloric conditions as mentioned previously, and whenever the intestine is so small that inversion of the edges would make a diaphragm and closure of the lumen. In such cases, the lateral method has proved to be an excellent substitute. Moreover, it avoids the disadvantages of the mesenteric space. It is performed by the purse-string method as follows:

For lateral intestinal or gastrointestinal anastomosis bring the two viscera into the desired relation and place a continuous mattress suture (Fig. 4, C), connecting

them through a length of from two to three inches, oval-shaped. Insert purse-string suture (P. S.) into each viscus one-quarter inch distant from and parallel to the continuous mattress suture (C). The purse-string sutures should be one-half inch shorter than the surrounding suture. With scissors or knife incise visceral wall within purse-string, trimming out strip of mucosa if desired, tie purse-string suture with slip-knot and, after both viscera have been thus treated, complete surrounding suture (C). After the latter has been placed, drawn sufficiently taut and tied, the purse-string sutures are untied and withdrawn by pulling gently on their loose ends.

DISCUSSION.

Dr. F. Gregory Connell, Oshkosh, Wis.: Improvements on the present attempts at aseptic intestinal technic are demanded. Dr. Walker's method and those of Muskowicz, E. Wyllys Andrews and Parker and Kerr are similar in principle to that of an Italian, Parlavecchio, which was published in 1897. They allow of a comparative asepsis, and will emphasize the necessity of the greatest care in an effort to avoid unnecessary soiling of the peritoneum by intestinal contents. Practical methods of union may now be performed in a comparatively aseptic manner; but when not to do enterorrhaphy has not ben emphasized. Breaks of continuity of the intestinal wall do not unequivocally demand immediate enterorrhaphy. The self-evident truth that a live patient with a fecal fistula is a more satisfactory result than is a corpse with a successful intestinal union, has occasionally been overlooked. Many points will have to be decided in the diagnosis before, during and after the operation, that if not judged correctly will render valueless a technically perfect enterorrhaphy, such as: When (in strangulation) to leave the bowel alone, or to perform enterectomy; when (in wounds) to perform simple enterorrhaphy, or resection; when (after enterectomy) to perform enterorrhaphy by end-to-end, end-to-side, or side-to-side union, or to establish an enterostomy; when (with stenosis) to do a resection, an anastomosis or an exclusion. To procure normal tissue, of which the blood supply is perfect, at the cut ends for suturing, it is sometimes necessary to remove apparently formidable lengths of intestine. Failure to secure such tissue is undoubtedly responsible for a large percentage of unsatisfactory results. To accomplish intestinal union the method of choice is that with needle and thread alone. A prime requirement of the suture is a secure stitch,

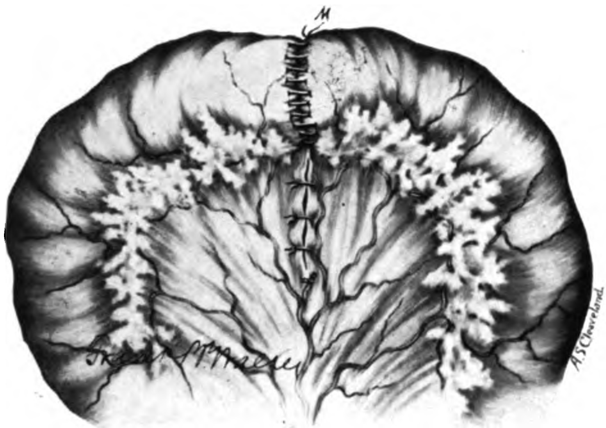


Fig. 3.- -This represents the continuous mattress suture (M) placed but not drawn taut. The purse-string sutures have been withdrawn. The mesenteric gap has been closed by three sutures.

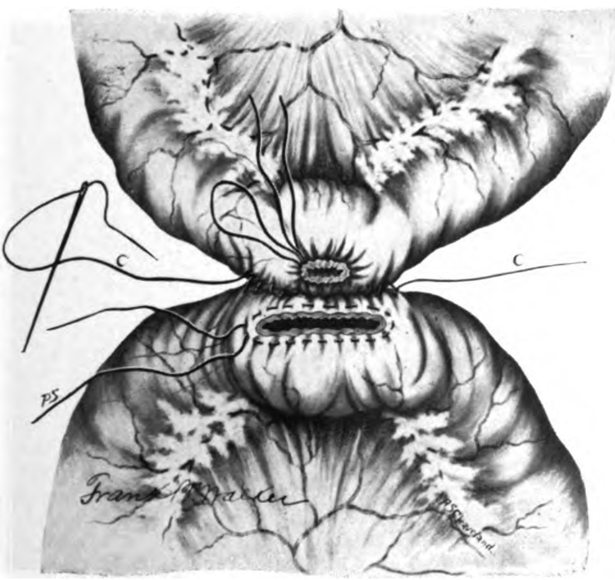


Fig. 4 —This represents two portions of intestine apposed and connected by a continuous mattress suture (C) through a short distance. In the lower gut a purse-string suture has been placed and the wall incised. In the upper gut the purse-string suture has been tied with a slip knot.

holding the cut ends in sero-serous apposition, or apposition continuously around the entire line of union, to secure which caution must be exercised at the mesenteric junction, because of the triangular space between serosa and muscularis formed by the anatomic arrangement of the peritoneum which allows a longitudinal strip of the intestine at this point to be devoid of serosa. The perforating, or through-and-through suture has been generally adopted as the important, security-giving, stitch. The use of a second row of stitches, including only the serosa and the muscularis, is at present looked on as merely a precautionary measure for the purpose of causing a broader sero-serous apposition and not to resist tension. Any stitch that enters the bowel lumen or comes into contact with the intestinal mucosa should be of non-absorbable material. This will remain in place until its usefulness is past, after which it will be eliminated into the intestinal current. Catgut, on the other hand, may be absorbed too rapidly. The secondary reinforcing sero-muscular stitch does not communicate with the lumen, and, therefore, may be of catgut. The time-saving feature and the hemostatic properties are perhaps the most important reasons why the continuous suture is employed more often than is the interrupted. Drainage will sometimes be necessary ofter enterorrhaphy, but not as often as in the past. The drain is to be placed adjacent to but not in contact with the line of visceral suturing.

Dr. A. J. Ochsner, Chicago: Dr. Walker's beautiful and ingenious operation must not mislead us into the idea that patients ordinarily die after intestinal operations because of the operation. They die because of the condition in which they are at the time they are operated on, or because of faulty surgical judgment. In intestinal operations, if the infection is still within the intestine, then death results from an unrecognized condition of the blood vessels. There is a thrombosis somewhere which results in a slough and kills the patient. Either the surgeon has not gone far enough beyond the seat of the disease or has traumatized the intestine, or has made the gross blunder of infecting the patient himself, which is practically a thing of the past among those who do intestinal surgery.

INVAGINATION OF LIMITED ANNULAR GANGRENE OF THE SMALL BOWEL VERSUS RESECTION.

JOHN E. SUMMERS, JR., M.D.
OMAHA.

It is the accepted practice and teaching of surgeons the world over, in cases of gangrenous intestine, to proceed to one of two lines of action: (a) The formation of an artificial anus, and (b) resection. "Whenever possible, i. e., in cases in which the condition of the patient, and the experience and help ready to the surgeon's hand admit of his taking this step, the gangrenous intestine should always be resected" (Jacobson and Rowlands). When the opposite conditions prevail, an artificial anus should be formed with the hope that this will prove a life-saving measure and that at a later operation the continuity of the intestinal canal can be re-established. The increasing experience of late years is tending more and more toward the selection of resection of the gangrenous intestine as against the formation of an artificial anus. This teaching emanates from good authority; it should, however, be accepted with some caution, as it is based on an ability in the selection of cases by men who are also especially skilled in intestinal surgery.

Most of the failures that have fallen to my lot in the management of patients with gangrene of the intestine have followed attempts to carry out the ideal; too much has been done, and this has been my observation of the work of others. It takes good common sense to weigh the pros and cons regarding resection in a given case of

gangrene of the intestine. The patient's condition must be fairly good to warrant resection.

The amount of gangrenous intestine a patient can carry and still be in a condition of resistance to admit of a successful resection has never been accurately determined. This amount may vary from one centimeter (3/8 in.) to two meters (6 1/2 ft.) and possibly more, but it is not always the extent of the gangrene that determines the resistance of the patient. A limited gangrene of short duration, accompanied by marked constitutional symptoms, is of graver import than one of an opposite type, i. e., one more extensive in the length of bowel involved, and longer duration of strangulation, but with rather mild constitutional symptoms. A resection in the former case must be made relatively twice as extensive as in the latter, because the mesentery has been invaded by infective products beyond the parts that appear healthy, even if the blood vessels do bleed freely on division.

The object of this paper is to call attention to a simple and safe manner of handling limited annular gangrene of the small intestine without resection, by invagination of the gangrenous bowel. Especially can I commend the procedure in those dangerous cases in which the success of a resection may be in grave doubt and the formation of an artificial anus the only alternative. The technic is applicable to the treatment of traumatisms to the small intestine from contusions and gunshot wounds, the repair of which, because of their peculiarly destructive, bursting character, if accomplished by suture, may so limit the lumen as to result in dangerous stricture or kinking of the bowel.

Case 1.—*History.*—In September, 1900, a young man was brought to the Clarkson Hospital, Omaha, suffering with a right inguinal hernia which had been strangulated for four days.

***Operation.*—He was in a condition of such marked collapse that I doubted the propriety of any surgical attempt. How-**

ever the field of operation was prepared, cocain injected (a general anesthetic was out of the question) and the hernial sac opened. It contained a loop of small intestine, a piece of which 4 cm. (1½ in.) long, was gangrenous, and although soft, was not very friable. The lumen of the bowel above and below the gangrenous ring was about the same, due unquestionably to the two days of stercoraceous vomiting which had preceded the patient's entrance into the hospital. As the man's general condition did not warrant a resection it occurred to me to make an intussusceptum of the gangrenous intestine, invaginating by manipulation sufficiently far so as to have sound tissues to suture at the neck of the intussusception, using for the purpose a circular continuous, sero-muscular stitch of silk. No attempt was made towards a radical cure of the hernia.

Postoperative History.—The usual restorative measures were employed and the patient's condition gradually improved. His bowels moved at the end of twenty-four hours and he made a good recovery. Six months after the operation I received a letter from him saying that he was in excellent health, but that he still had his hernia.

Case 2.—*History.*—In the autumn of 1907 an elderly man was sent to me by Dr. Hill of Lyons, Neb., suffering with a strangulated, right oblique inguinal hernia. When the man arrived at the Omaha General Hospital the strangulation had been in existence some fifteen hours, but he was in excellent condition.

Operation.—An immediate operation under ether, was done. The bowel was found to be in the same condition as in Case 1, with the exception that the gangrenous ring was not quite so extensive. An intussusception was formed after passing four equidistant sero-muscular, Halstead mattress silk stitches around the circumference of the bowel—i. e., parallel to its long axis. In making these stitches the needle was entered first 1.5 cm. (½ in.) below the gangrenous ring and then at about the same distance above it, and then back again near the point of starting. As the ends of these stitches were pulled on by an assistant, the invagination was aided by grasping the bowel below the stitches, between the index and middle fingers, and pulling upward, while, with the thumb above, pressure was made downward—a method similar to that employed in reducing a paraphymosis. Great gentleness, was, of course, exercised in making this manipulation. After tying the Halstead stitches the line was reinforced by a circular sero-muscular silk stitch. A Ferguson operation for the

radical cure of the hernia was then done. The man recovered without complications and has remained well since.

CASE 3.—*History.*—In December, 1907, a boy, aged 16, was accidentally shot in the abdomen with a 0.32 caliber pistol and was operated on by me nine hours later in the Omaha General Hospital.

Operation.—There were twelve perforations of the small bowel, all very easy of repair except one which was so destructive (explosive) in character that to suture it would practically have closed the lumen of the bowel. Neither was it possible to trim the edges of the wound so as to form a rhomboid that could be sutured advantageously. It was a resection and nothing less, unless the injured bowel could be treated as in Cases 1 and 2. The latter was done, about 3.5 cm. (1¼ in.) being invaginated. No complications ensued and the boy made a good recovery.

In a similar case it would be more surgical to destroy, by crushing with an angiotribe forceps, the ragged flaps of the wound before making the intussusception, thus assuring a smooth surface within the bowel at the line of suture. If the extent of gangrene involves more than 5 cm. (2 in.) of the intestine, it would certainly be necessary, before making the invagination, to deal with the mesentery by freeing it from the bowel and resecting it or not as the condition indicated.

There are possibilities of usefulness of the technic described in this paper by extending its employment to the treatment of annular strictures of the intestines, small and large. These strictures can be removed *per vias naturales* after devitalizing the bowel above and below with an angiotribe forceps and invaginating the devitalized diseased structures into the bowel to be passed off as an intussusceptum. There are also other possibilities along the same line, for example, in relation to resections.

There may be mechanical contraindications to the technic offered; (a) when a loop of gangrenous intestine longer than 10 to 12 cm. (4 or 4½ in.) would appear rather difficult to manipulate, or (b) when the bowel is thick and edematous immediately above the

gangrene, or very much contracted below it, the difficulties of invagination may be insurmountable. However, the distended bowel above can be reduced by employing Monk's method of using a glass tube to relieve the distention.

I am sure that a dead piece of intestine may be invaginated upward, and if a properly reinforced through-and-through continuous silk suture is employed, making the neck of the intussusception broad and strong, there will be no giving way, but the current in the intestinal tube will pass naturally with the sloughing off of the intussusceptum. Senn's experimental work in this form of invagination carries no contradiction to the above statement.

I make no pretense to being the first surgeon to invaginate a gangrenous loop of bowel when otherwise a resection or the establishment of an artificial anus must have been done. It was original in so far as I, personally, was concerned, and I had been led to believe from the best obtainable sources that the procedure was new. Alas, there is little new under the sun. Professional medical bibliographers and others had failed to find references to the technic, but I discovered in my own library, after this paper was written, that Guinard reported, at the French Congress of Surgery in 1895, a case of gangrene of the small intestine in which he successfully invaginated 9 cm. (3½ in.)—and many practical surgeons may have done similar work.

My own experience with this technic is so limited that I do not feel warranted in saying very much for it, but I am convinced, nevertheless, that I could have applied it with advantage to my patients in many resections for gangrene and other lesions of the intestine which I have done since my first application of the principle in 1900.

DISCUSSION.

Dr. Archibald MacLaren, St. Paul, Minn.: It seems to me that Dr. Summers' suggestion is excellent and that it opens a field of great usefulness, especially the suggestion of

the use of the angiotribe. Dr. Lund says that in Boston they have pursued this course in a number of instances, but never published the work.

Dr. L. L. McArthur, Chicago: Dr. Summers' paper describes an extension of a method which both Dr. Bevan and myself have been utilizing in cases of gangrene of the bowel when small in extent and involving only a section of about one-third of the circumference of the bowel, as may be found in the gangrene which accompanies Littré's hernia, simply invaginating that segment of the bowel. Dr. Summers has shown that it is possible to go further and introduce into the bowel a gangrenous mass 4 to 8 c.c. in length, but smaller than an intussusception, and get good results by the sloughing off of the mass. I believe that he has added to our armamentarium very decidedly.

ACUTE DIVERTICULITIS OF THE SIGMOID, WITH OPERATION BEFORE RUPTURE.

GEORGE EMERSON BREWER, M.D.
NEW YORK.

In an earlier paper[1] I reported the histories of six patients operated on for intra-abdominal suppuration. In each case I believed the infection to have been caused by inflammation of an acquired diverticulum of the left colon.

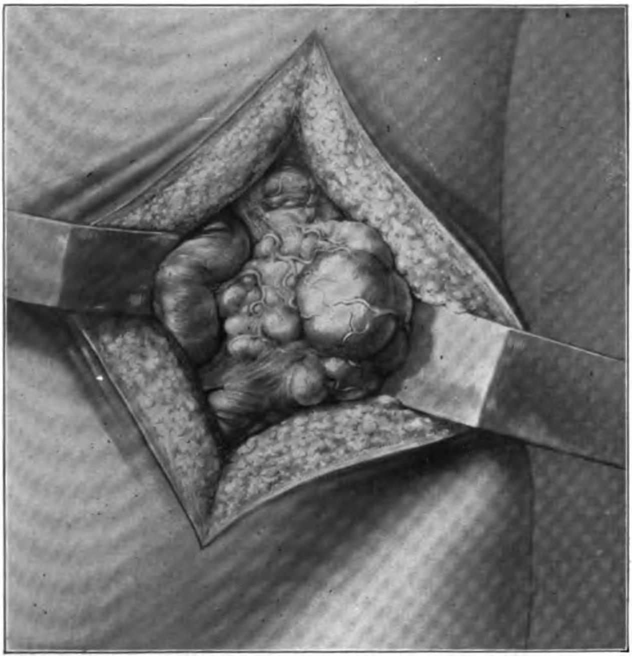
In two of these cases I was able at operation to demonstrate a gangrenous rupture of the diverticulum of the sigmoid, in each of which an oval concretion was found which had acted as a predisposing cause of the infection.

Since the publication of that paper one of the patients reported, in whose case an acute diverticulitis was demonstrated, experienced a second attack and was successfully operated on by my assistant, Dr. Carleton P. Flint.

As this is the only recorded instance in which an individual has recovered from two operations for this condition, and as it is the first case of acute diverticulitis of the colon in which diagnosis has been made and operation performed before rupture had taken place, I felt that it was of sufficient interest to warrant my presenting it.

Patient.—This was a man 45 years of age. He had always enjoyed good health; had never suffered from digestive disturbances, suggesting appendicitis, gallstone colic, or peritonitis.

1. Etiology of Certain Cases of Left-sided Intra-abdominal Suppuration, read before the American Surgical Association, May, 1907.



Acute diverticulitis of sigmoid.

First Attack.—In August, 1902, while at dinner he was suddenly seized with an attack of abdominal pain, nausea and faintness, which necessitated his leaving the table and retiring to his room. The attack soon passed off and he was able to join his friends later in the evening. The following night proved a restless one, as he had more or less constant pain in the lower portion of the abdomen, which prevented sleep, and at times was accompanied by nausea and general bodily weakness. The following day he continued to feel badly, but kept up and about for the reason that he was a guest at a country house, and did not wish to inconvenience his host. Later in the day he went for a drive and suffered acutely from the jolting of the vehicle. In the evening he was obliged to call a physician, who, after examination, pronounced the case one of colitis. He returned to the city the following day, and as the symptoms continued, he remained in bed. During five days he continued to suffer with pain in the lower left quadrant of the abdomen, fever, and general malaise.

Examination.—When first seen by me the temperature was 103; pulse, 110; leucocytes, 17,000. There was marked rigidity of the left rectus muscle and a tender mass in the iliac fossa.

Operation.—He was immediately removed to the Roosevelt Hospital, and under ether anesthesia, an incision was made over the most prominent portion of the tumor. After dividing the tissues of the abdominal wall, a large abscess cavity was entered, which contained about 120 c.c. of foul pus, and an oblong, fecal concretion. On washing out the abscess cavity a small ulceration was seen in the wall of the sigmoid, through which escaped a small amount of fecal matter. The cavity was packed with sterile gauze, the wound partly united, and a dressing applied.

Course of the First Operation.—After operation the temperature and pulse rapidly declined to the normal, the pain ceased, and the appetite returned. The discharge from the abscess cavity gradually diminished, until a cathartic was administered on the fourth or fifth day. This gave rise to a very abundant fecal discharge, which continued for several days. It gradually diminished after this period, and the sinus finally closed in about six weeks from the time of operation. The patient remained in perfect health for a period of five years and four months.

Second Attack.—In January of this year he experienced an acute pain in the abdomen, accompanied by nausea and general malaise. The pain at first was more or less generalized over the entire abdomen, but later became localized in the left

iliac region, and was so similar to his previous attack as to at once suggest to the patient's mind a repetition of his former illness. The temperature was moderately elevated, and the pulse accelerated. As I was unable on account of illness to respond to his summons, I asked Dr. Flint to see him.

Second Examination.—At the time of Dr. Flint's first visit the pulse was 80; temperature, 101; leucocytes, 15,800; 80 per cent. polynuclears. The abdomen was not distended. On palpation there was felt a well marked muscular rigidity in the left inguinal and lumbar regions, more particularly to the outer side of the left rectus muscles. This region was sensitive to the touch, the point of greatest tenderness being midway between the anterior superior spine of the ilium and the umbilicus. On deeper palpation a distinct mass could be felt about the size of a small orange, near the anterior spine. This mass was exquisitely sensitive to the touch, and seemed to lie directly beneath the scar of the old operation. Examination of the lungs and heart was negative. The free border of the liver could be palpated about one inch below the costal margin. The spleen was not felt. There was no costovertebral tenderness. The urine was turbid, acid, 1031, contained no albumin, sugar, pus or blood.

An ice-bag was placed over the tender area and the patient passed a restless night. On the following morning the temperature was 100; pulse, 82; tenderness and muscular rigidity about the same. There was, however, rather more spontaneous pain, which was of an aching character. Later in the day the temperature rose to 102.5; the pulse-rate was increased, and the patient complained of more pain and tenderness. On examination the mass seemed somewhat larger, but this was difficult to appreciate on account of the fact that the muscular rigidity was considerably increased, and now involved the lower two-thirds of the rectus muscle. As it was evident that the condition was a progressive one, Dr. Flint made the diagnosis of acute diverticulitis, and ordered the patient's removal to the Roosevelt Hospital for operation.

Second Operation.—After the usual preparation, under ether anesthesia, an incision was made directly over the mass, which excised the scar of the previous operation. Incision was deepened until the peritoneal coat was reached. An attempt was then made to expose the sigmoid on its outer aspect, which was the seat of the previous abscess. This was, however, abandoned on account of the dense adhesions, which existed as the result of the previous infection. The peritoneum was next opened somewhat nearer the midline, and a small amount of turbid serum escaped. The intestines lying in the left iliac

fossa were moderately injected, and in places glued together by a fibrinous exudate. On exposing the upper part of the sigmoid it was found to be deeply injected and edematous. On the median side of the gut near its mesenteric border, and extending well on to the median leaflet of the mesosigmoid was an oval inflammatory mass 8 or 10 cm. in its longest diameter (Fig. 1). This mass was apparently made up of an acutely inflamed diverticulum covered by edematous peritoneum, to which there were attached a number of greatly swollen appendices epiploicæ. The inflamed area was acutely red, very edematous and covered with a number of enlarged and tortuous blood vessels. On gentle palpation the tumor was found to be fluctuating; it evidently contained a quantity of pus. The colon was exposed and examined for some distance above and below the inflamed lesion to detect the presence or absence of other diverticula. As none were found, an attempt was made to draw the loop of sigmoid through the abdominal wound with a view to treating the lesion by the extraperitoneal method. This was found to be impossible on account of the dense adhesions from the previous operation. The parietal peritoneum was then drawn tightly around the inflamed diverticulum, and held snugly in place by a few catgut sutures at its upper and lower angles. The exposed diverticulum was then surrounded by several layers of sterile gauze, which served also to press the parietal peritoneum snugly against the loop of sigmoid and its mesentery. The wound was then drawn together at its upper and lower angles and united with silk wormgut sutures. In this manner the peritoneal cavity was completely closed, leaving only the enlarged and inflamed diverticulum exposed in the bottom of the wound.

Course After Second Operation.—The patient made a satisfactory recovery from the anesthetic, and with aid of a moderate amount of morphin passed a comfortable night. In the morning the temperature was 101, the pulse 88. The patient passed a fairly comfortable day, there being practically no reaction from the operation. On dressing the wound at the end of forty-eight hours, it was found that two small perforations had formed, through which there exuded a moderate amount of foul-smelling pus. Later the diverticulum was freely opened, and a minute opening found, which communicated with the lumen of the bowel. From this time on the treatment consisted in daily dressing with irrigation of the wound and subsequent packing with sterile gauze. The temperature rapidly fell to the normal, the pain ceased, the appetite returned, and the bowels moved. The amount of fecal discharge from the intestinal wound varied from day to day,

but was never large. The fistula finally closed about three weeks after the operation.

Last Stage of Operation.—On the twenty-seventh day, as the necrotic walls of the diverticulum had entirely separated, and as the wound was well covered with healthy granulations, an attempt was made to replace the exposed portion of the intestine and to close the wound. Ether was administered, and after a thorough cleansing of the tissues, the parietal peritoneum was partly separated from its adhesion to the margin of the bowel and mesentery. The presenting structures were then pressed inward and the separated muscles drawn together by silk wormgut sutures. The peritoneal cavity was not opened. A small drain was left in the center of the wound on account of the possibility of a reopening of the intestinal fistula. No reaction followed the operation. Wound united by first intention, and the small central opening for the drain quickly filled with granulations.

Postoperative History.—As the patient was rather a stout individual, and as the abdominal muscles were somewhat flabby, he was not allowed to sit up until three weeks after the second operation. A few days later he was discharged from the hospital in excellent physical condition.

From my experience, acute diverticulitis, like appendicitis, may be divided into four clinical groups:

Group 1, in which there is a mild inflammation of a diverticulum, which subsides like a catarrhal appendicitis under rest and appropriate medication.

Group 2, in which the inflammation is more severe and progressive, in which the diagnosis is made and operation performed before rupture takes place. As the opening connecting a given diverticulum with the intestine may be small, the acute inflammatory process may serve to completely occlude it, and empyema of the diverticulum with or without the presence of a concretion may develop. The last attack of the patient reported in this paper would be an example of this type of the infection.

Group 3 would comprise those cases in which there has been a rupture of the diverticulum, with the formation of a localized abscess, either intraperitoneal, or, if the diverticulum is situated in a portion of the intes-

tine not covered by the peritoneum, the entire process may be without the peritoneal cavity. The history of the first attack of the patient reported would correspond with this type of the disease.

Group 4 would include all cases in which a rupture of the inflamed diverticulum into the free peritoneal cavity had taken place, with a resulting spreading or generalized peritonitis. I reported an example of this type of the disease in my previous paper.

In general, it may be stated that the symptoms and signs of acute diverticulitis are practically identical with those of acute appendicitis in its various forms, the only difference being that the former occurs as a rule on the left rather than on the right side of the abdomen.

Sufficient data are not available to enable one to determine what percentage of inflamed diverticula actually perforate, and it is therefore not possible to state dogmatically whether a given case of acute diverticulitis with comparatively mild symptoms should be subjected to immediate operation or should be treated more conservatively. In my opinion, however, the clinical course of the disease is so similar to the various forms of acute appendicitis that the treatment should be the same. Certainly in all acute cases, with severe and progressive symptoms, safety lies in early operation. Had operation in the case reported been delayed, rupture would undoubtedly have taken place within twenty-four hours, and in all probability would have resulted in a rapidly spreading peritonitis.

Regarding the operative technic of the treatment of an inflamed or gangrenous diverticulum, my experience has been far too limited to lay down any hard and fast rules. In my judgment, however, if the diverticulum is small or attached to the bowel by a narrow pedicle, removal, with closure of the intestinal wound by a purse-string or several Lembert sutures, would be indicated, providing the surrounding intestinal wall was not too

much infiltrated. In the event of the diverticulum being large, attached by a broad base, or covered by a plexus of enlarged vessels, the safest method, in my opinion, would be the one employed in the case reported, that is, extraperitoneal drainage. If the situation of the lesion is such that extraperitoneal treatment can not be carried out, I suggest packing with gauze, from the abdominal wound to the lesion, leaving this packing in place from forty-eight to seventy-two hours, or until firm adhesions have formed about the gauze column; then removal of the gauze and free opening of the abscess, allowing it to drain through the channel thus formed.

If rupture has already occurred the intestinal wound should be united by suture, if this is possible; if not, adequate drainage should be provided.

61 West Forty-eighth Street.

DISCUSSION.

Dr. D. N. Eisendrath, Chicago: This left-sided affection of the abdomen is one that must be considered in the future differential diagnosis of abdominal conditions, and it is necessary to have a clear conception not only of the acute forms of this disease, but of the chronic forms as well. Up to the present time there have been comparatively few cases of diverticulitis reported, either acute or chronic. In a recent number of the London *Lancet* one of the most thorough articles on the subject appeared by Cullen, who collected reports of 105 cases of all clinical varieties of this disease. I believe that in a few years we shall find that it is a comparatively frequent affection of the abdomen.

I had almost forgotten up to the time of seeing Dr. Brewer's first paper a case of my own which has never been published. The patient was a clerk, about 42 years of age, whom I did not see until symptoms of peritonitis were well advanced. My first thought was of appendicitis as the cause, but when the abdomen was opened the appendix was found to be normal. On the left side we found in the sigmoid region a perforated appendix epiploica, undoubtedly the cause of the trouble. Eighteen such cases of peritonitis following ruptured diverticulitis have been reported.

The chronic forms of the disease are beginning to explain many hitherto obscure abdominal lesions. One form is due to connective tissue formation, a chronic proliferative inflamma-

tion in the submucous and serous coats producing intestinal stenosis. This may give rise to symptoms of chronic or acute obstruction whose pathology would never be clear unless we understood the subject of diverticulitis. A second way in which the symptoms differ from those of chronic appendicitis is in the formation of enteroliths simultaneously in large numbers of these diverticula. For example, a man 78 years of age had a herniotomy. In the sac lay the sigmoid, which was filled with a large number of enteroliths, each in a diverticulum.

The adhesions formed in the chronic diverticula result in a series of pathologic changes, such as obstruction of the intestines due to changes in these diverticula. The etiology of these so-called vesico-enteric fistulæ was very obscure until it was found that they were caused by adhesions of these diverticula to the bladder, with subsequent perforation. With the information thus gained we have been able to operate on a very large number of cases. The interesting feature in these chronic forms of diverticula is the resemblance of these proliferative forms to carcinoma. There is no doubt that many cases in which a diagnosis of carcinoma of the sigmoid was made were in reality cases of chronic diverticulitis with stenosis.

Dr. P. E. Truesdale, Fall River, Mass.: I present a few cases to suggest the use of the colon bacillus vaccine in abdominal operations when this organism is or may become a factor in an infectious process. In operations on the large bowel, as you know, the best results are attained by first emptying the colon, then allowing it to remain in a condition of absolute rest for at least twelve hours before operative intervention is done; this with a view to eliminating the number and activity of the colon bacilli. In addition an immunizing dose of stock vaccine should be given.

A woman, aged 24, married, had acquired gonorrhea at the age of 21. During the first attack she remained in bed one month with active pelvic inflammatory symptoms. Exacerbations occurred every month or two afterward. In June, 1906, she was operated on for a tumor in the lower abdomen which had increased rapidly in size during the three months preceding the operation. A multilocular cyst as large as a seven months' uterus and apparently of inflammatory origin was found. Everywhere adherent to the omentum were the large and small intestines. While the tumor was being delivered from the abdominal cavity, an examination of the under side revealed a papilliferous degeneration in union with the sigmoid. In separating the bowel from the tumor it was found that for an area involving one-half of its circumference and about four inches of its length, all the layers of the intestinal wall had sloughed away, and the wall of the tumor supplemented the normal structures. Liquid feces escaped into the field of operation. In the midst of this infected area it was

deemed unsafe to make an anastomosis so that a muscle-splitting incision was made in the left side, the ruptured sigmoid was clamped at either end, drawn through this incision and sutured to the skin. The main tumor was then dissected free from its attachments and with double pus tubes was removed, the peritoneal cavity carefully wiped out and the incision closed, leaving a drain in the pelvis.

It was early apparent that there was an active infection in the median incision and the colostomy wound. The temperature and pulse were high; the phlegmonous infiltration increased rapidly until it involved the abdominal wall to the margin of the ribs. An incision was made through the skin in the flank but it was apparent that no ordinary means of local treatment could control the infectious process. The case seemed hopeless and the vaccines were tried as a last resort. I believe that they turned the tide in favor of recovery.

The second case was that of a school teacher, 21 years old, who had a first attack of pelvic disease in June, 1907, and symptoms of pelvic disease with digestive disturbance and constipation, alternating with diarrhea, since the time of attack one year ago. Ten days before I saw her she developed acute symptoms with chills, fever, pain and tenderness across the lower abdomen, especially marked on the right side.

Her physician supposed that she had appendicitis and advised operation because at the end of this time her temperature was going higher and her condition became conspicuously worse. Examination showed what was thought to be pelvic disease; temperature was 102, pulse between 120 and 130. At the operation a large pelvic abscess was discovered in the center of which were the right appendages. Pathologic examination of these specimens proved them to be tuberculous. The infective mass was separated from its adhesions and removed.

No opening of the rectum was discovered at this time, but after operation, when the patient was given salt solution, it came through the drain on the abdominal dressing, mixed with fecal matter. The wound soon showed evidence of infection and began to break down. The vaccine was administered, 0.25 c.c. for the first dose. Soon afterward the appearance of the wound changed and a cleaner process of healing was evident. The culture from the discharge showed *Bacillus coli* and *Staphylococcus aureus*.

The third patient, also a school teacher, aged 51, had the acute attack for forty-eight hours before the operation. At the end of twenty-four hours the abdominal pain was very severe with vomiting. An osteopath was called and administered treatment, which relieved the pain in the right upper abdomen. For the next six hours she was comparatively comfortable, but then she began to have pain in the right lower quadrant, which soon became general in the abdomen.

Her physician was summoned and his diagnosis of peri-

tonitis from a ruptured appendix was followed with advice for immediate operation. I saw the patient forty-eight hours after the onset of her attack and twenty-four hours afterward she was relieved by the osteopathic treatment. Her abdomen was distended, her knees drawn up, her facial expression anxious; she was everywhere tender over the abdomen, but this was most marked in the right lower quadrant where there was also muscularspasm.

I, too, believed that her peritonitis was due to a ruptured appendix as it was only after discovering the lesion that I could attach the important bearing of the rubbing that she had received for her pain in the upper abdomen. However, in view of the history of gall-bladder disease, an incision was made on a level with the umbilicus at the outer border of the rectus muscle. When the peritoneum was incised seropurulent fluid escaped and with it a small gallstone. The incision was enlarged upward. There was general peritonitis, a few adhesions around the gall bladder; the appendix was normal; the gall bladder was perforated near its base, and muco-pus was escaping. The gall bladder was extirpated, a drain placed in the wound and in the pelvis, the patient put to bed and given 0.25 c.c. of colon bacillus vaccine. A culture was taken from the gall bladder and from the fluid, which proved to be a pure culture of colon bacilli. Convalescence progressed uneventually; pain and distention subsided and the patient passed gas, and all symptoms of peritonitis disappeared in the subsequent twenty-four hours. There was then a slight rise in the temperature. The vaccine was administered—0.5 c.c.—and the course of the temperature changed.

The results in these cases are encouraging. If we accept the opsonic theory on which the vaccine therapy has been laid down by Wright and others, and we find that a specific organism is the common cause of infection in the bile ducts and pancreas, we are thereby in a position to treat these cases on more scientific principles. The acute infectious cases may, at least, be given trial doses of vaccine, for this does no harm, and if by its action we can control the acute process, these patients may be operated on during the interval for the removal of their gallstones and the cure of the chronic inflammatory lesions in the bile passages and pancreas. So, too, in operations on the large intestine, where the colon bacillus is ever present, by immunizing the patient before operation, the scope of the surgeon may be greatly increased and his results as greatly enhanced.

Dr. L. L. McArthur, Chicago: The *Staphylococcus aureus* and the colon bacillus are the two organisms which show a very pronounced effect when used as a vaccine, and Dr. Truesdale's suggestion to use them is excellent.

SOME PRINCIPLES OF CEREBRAL SURGERY.

HARVEY CUSHING, M.D.
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In the presence of an extrauterine pregnancy, of an inflamed appendix, of gallstones, of pyloric stenosis, or what you will, of the many intra-abdominal lesions so frequently encountered, how many surgeons feel less competent to recognize the condition than their colleagues who are disinclined themselves to handle scalpel and forceps? And further, would these very colleagues be willing for a moment to call the surgeon in consultation on these cases if they did not feel assured that he is as familiar as they themselves with the anatomy and physiology of the organ concerned and the morbid processes, with their complications, to which it is liable?

One of the trying responsibilities of many physicians arises from the consciousness that they must protect their patients from the over-zealous interest of the chance operator, whose manual facility exceeds his knowledge of disease, an attitude almost as deplorable as that in which the trained surgeon may find himself with his opportunity to relieve slipping by, owing to the procrastination of the attendant who favors surgery not at all, or as the last resort only.

Yet neither party would be willing to recall the day, not far remote indeed, when the physician selected the instruments for and directed the course of an operation so simple as a herniotomy, the "Bruchschneider" having been merely the more skilful hands for the better in-

formed mind and superior judgment of the physician. Under this relation the advance of surgical therapy was necessarily slow, if not indeed often backward, and strides were not made in this manipulative division of therapeutics until the Hunters and the Hallers, the Bells and the Brodies, the Langenbecks and the Listers began to place a knowledge of the condition of disease as the chief asset of the surgeon—not his mere familiarity with probe and bistoury.

And yet this is the condition of things which pertains to-day in neurology; and it is putting the cart first for us surgeons to talk wisely about the technic of neurologic surgery if we know so little about the maladies toward which these measures are to be directed. Operations become dangerously safe under such circumstances, and if we do not invade this uncertain field most cautiously we may be open to the same criticism not unjustly cast on the activity of certain laparotomists, likened to the inquisitive child who cuts a hole in a drum-head to see where the noise comes from.

As surgeons approaching neurologic maladies, what most of us need, therefore—a "finger and thumb" knowledge of neurology—can only be obtained with labor, patience and tears, for even the best of our schools do not as yet particularize on the relation of surgical measures to diseases of the nervous system, as they have come to do in the case of the eye and ear, of the pelvic and genitourinary organs, of the alimentary canal, the bones and joints, and what not, though it is a still more specialized form of work. Thus it is, I think, that those who look forward to a career in neurology should be instructed in matters of surgical technic—in other words, that a school of neurologists must grow up in the next generation with a general surgical training which will enable them to do their own operations. Now they can only stand by and wring their hands at the incompetency of much of the work that is being done for them by others.

After this preamble, which is indeed the most important of the things I shall have to say, I may pass to the brief consideration of the few principles which I desire to emphasize.

FUNCTIONAL DISTURBANCES.

Practically all diseases, whatever they may be, have a certain superstructure of symptoms, which we choose to call functional, superimposed on those for which an actual organic lesion is clearly responsible. This superstructure may often so overtop the basal trouble, which may actually be trifling, as to completely obscure it, and neurasthenic or psychesthenic states result. This is especially true of lesions which primarily affect the nervous system itself; and no class of patients require so much personal direction and moral control as do many of these unfortunates.

Oftentimes the relief of the functional element is more to be desired than the cure of the organic lesion, even if one be recognized; and it is one of the deserved criticisms of many operators that we are apt to let our patients go with their organic lesion healed—may we say cured?—but with their functional distress unabated or even accentuated. It lies within the power—indeed it is the duty—of the surgeon who takes these cases in charge, not only to remove or improve the condition of the underlying lesion, if that is possible, but to attend as well to these so-called neuroses, and it is for this reason, if for no other, that he must not only get intimately in touch with his patient by a history and thorough personal examination, but must also attend himself to every detail of operative preparation and after-treatment. Whether he exercises its power consciously or—as is true of many of the most successful therapeutists—unconsciously and as a natural gift, what has come to be "dignified" as psychotherapy must be the neurologist's constant resource, be he surgeon or otherwise.

ANESTHESIA.

Among the numerous details of a cranial operation there is one thing I particularly wish to dwell on—the administration of the anesthetic[1]. In cranial operations in particular, not only because of the cramped field and the need of a covering for the anesthetist, but also because the cardio-respiratory centers in the medulla are often already embarrassed through pressure, anesthetization by an expert is absolutely essential. There are trials enough for the surgeon in these cases without the added anxiety in regard to narcosis. For the past few years Dr. S. Griffith Davis, who devotes his time almost exclusively to this work, has greatly lightened these responsibilities for me by giving anesthetics to all of my neurological patients, and the fact that in more than three hundred cranial operations there has been a complete absence of the calamities usually assigned to anesthesia is attributable entirely to his skill.

Owing to the difficulty in cranial work of shutting off the anesthetist from the operative field, many have advocated rectal or other bizarre forms of administering the various drugs employed for this purpose; but we have been so free from accidents on this score and have learned to arrange so securely the operative sheets as to make a hood which effectually conceals the anesthetist and leaves exposed only the immediate small field of operation (Fig. 1), that we have clung to the more familiar and, I think, safer method of inhalation anesthesia.

I have described elsewhere[2] our invariable custom of shaving such portion of the scalp as needs to be prepared, just before the operation; of placing the patient on the table in the most comfortable position compat-

1. The general disregard of the risks of anesthesia, particularly in this country, has been deservedly arraigned by John B. Roberts: The Anesthesia Peril in American Hospitals. Therapeutic Gaz., February, 1908.

2. Technical Methods of Performing Certain Cranial Operations. Sur., Gyn. and Obstet., March, 1908, 227.

able with a good operative exposure before the anesthetization is begun; and of superficially outlining the proposed incision on the scalp after its final cleansing and before the small operative field is securely and closely surrounded with the sheets and towels, which are often pinned directly into the scalp to insure against their dislodgment during the course of what may be a long operation.

The large sheet which covers the etherizer is provided with a semicircular notch cut into one side, at the angles of which are fastened tapes to be tied around the patient's head, thus securely anchoring the coverings in such a position as to expose merely the area of the incision previously scratched on the scalp.

The two alternatives to this method—(1) the shaving of the head the day before with delineation on the scalp of the cerebral fissures or of the proposed incision with an indelible pencil, or (2) the leaving of the head so exposed after the final preparation of the field that the bony landmarks can then be utilized for these determinations at the time of operation—both possess serious drawbacks.

To some, these may seem petty details, but the total freedom from infection, even as a stitch abscess, in a series of three or four hundred craniotomies justifies the attention paid to them.[3]

I have already spoken of the fact that these patients, particularly in the presence of tumor, not infrequently show evidence before the operation of some respiratory embarrassment, and for this reason the administration of the anesthetic on the table in a position which assures free respiratory movements is a most essential precaution. A special form of outrigger with head and shoulder supports (Figs. 2, 3 and 4) has been found necessary, however, only for suboccipital or high spinal opera-

3. The only cranial operation in my entire series in which the wound has become infected occurred in another city where I had been persuaded to perform a decompressive operation for tumor, and where it was impossible to follow our usual routine.

Fig. 1.—Photograph taken during the course of a craniotomy. Just before elevation of an osteoplastic flap, to show well protected field and hood for anesthetist.

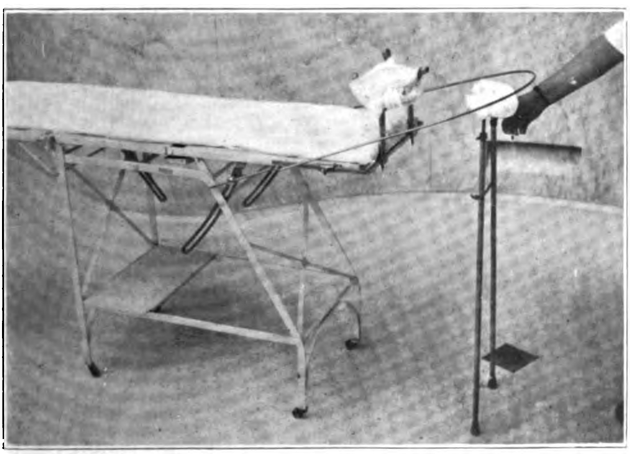


Fig. 2.—Showing table for cerebellar operations with outrigger shoulder supports, crutch for head, and hoop to support operative sheets.

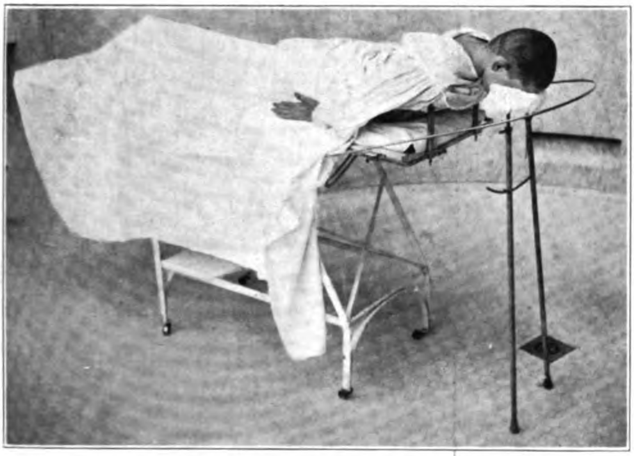


Fig. 3.—Same as Fig. 2. Patient in position before anesthesia.

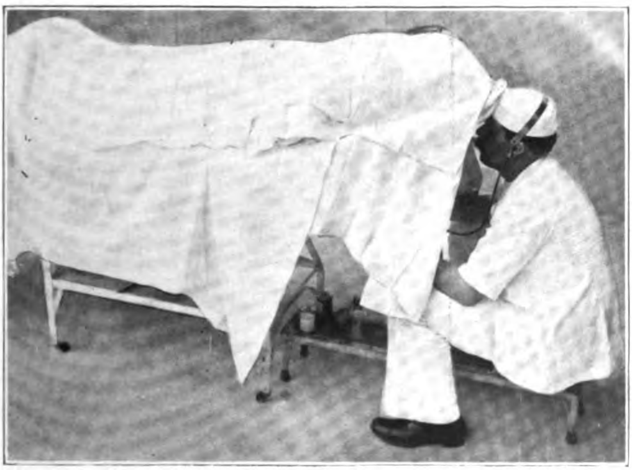


Fig. 4.—Same as Figs. 2 and 3. Anesthetist wearing headband with receiver and tube leading from phenendoscope.

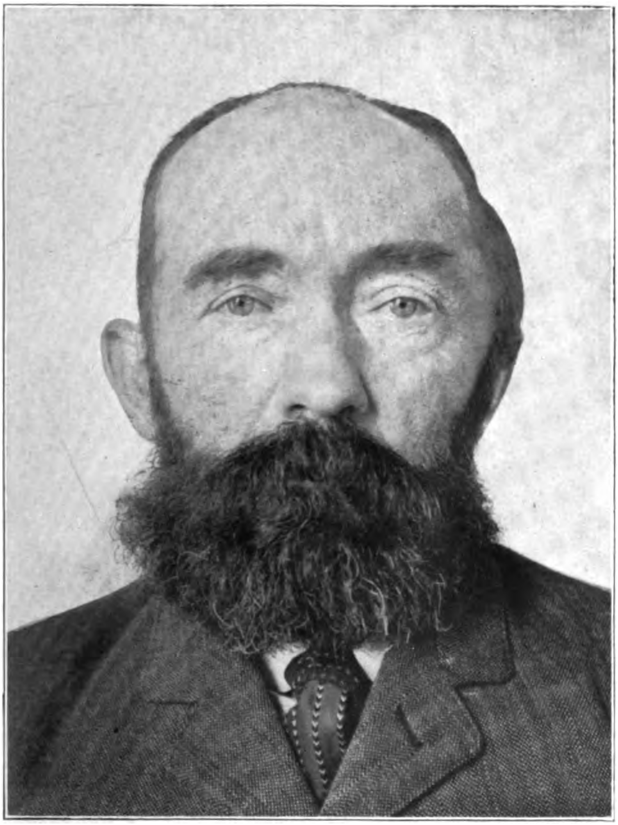


Fig. 5.—Showing fairly large left subtemporal protrusion six months after decompression for unlocalizable growth. Patient in perfect health and actively engaged in his occupation as a farmer.

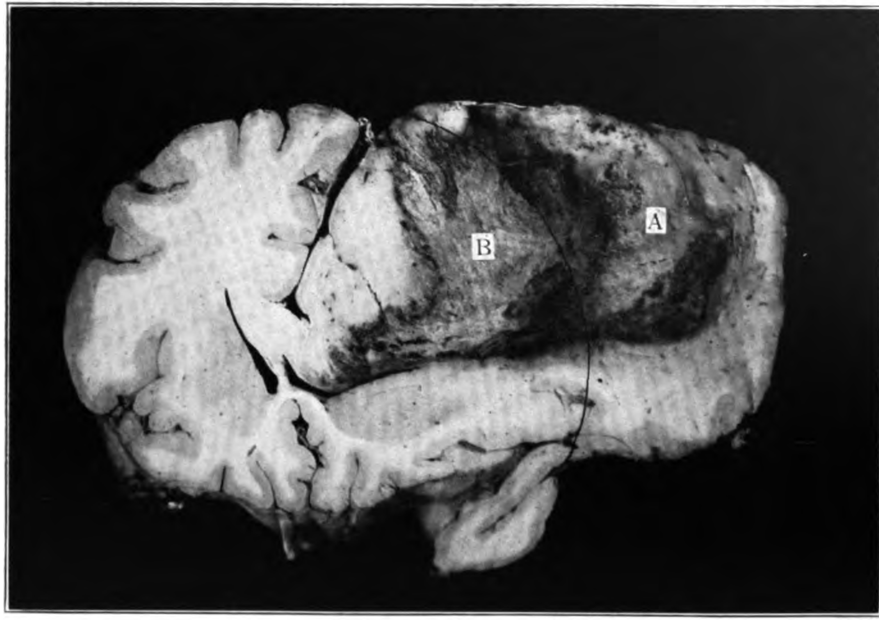


Fig. 6.—Large glioma (A) of right hemisphere leading to contralateral hemiplegia and hemianesthesia, with enormus hernia which followed exploration and decompression directly over the growth, in consequence of hemorrhage (B) into the substance of the tumor owing to dislocation. Extent of protrusion shown by position of curved line.

tions in which a symmetrical exposure is desirable, for reasons—on the principle of dislocation—to be explained later.

I was led to adopt such a table extension owing to the respiratory difficulties which patients experienced[4] when placed in a prone position without such supports, and further by the added difficulty to the anesthetist which this position otherwise engenders. Since its adoption these posterior operations, so far as position goes, have proved no more trying than those on the more accessible cranial vault. It has been possible in my 24 cerebellar cases, largely owing to this device, to complete the operation in one sitting and thus to avoid a "two stage" performance—especially undesirable in suboccipital work.

With a patient in this prone position it is difficult for the anesthetist to gauge fully the variations in cardiac action, and during the past six months Dr. Davis has employed in these, as in all other operations indeed, a simple device, so satisfactory that we wonder why it has not long since come into general use—namely, the *continuous ausculation of cardiac and respiratory rhythm during the entire course of anesthesia.*

The idea arose from a practice in the Hunterian Laboratory of auscultating the heart during the production of experimental valvular lesions, and like other things has been carried from laboratory to clinic. The transmitter of a phenendoscope is secured by adhesive strips over the precordium and connects by a long tube with the anesthetist's ear, where the receiver is held in place by a device like a telephone operator's headgear (Fig. 4). Uninterrupted information of the patient's condition is thus given, and the anesthetist need not disengage a hand for the occasional palpation of the pulse, which is

4. My first operation for a cerebello-pontine tumor resulted in a death from inhalation pneumonia—an experience which led to the adoption of this particular form of table extension. Since its employment I have had two successful extirpations of these lateral recess growths.

the brain, often leads to hemorrhage into or around a vascular growth, which greatly augments its size and may lead to an enormous hernia (Fig. 6). In other words, an exploratory operation turned into a palliative or decompressive measure may be disastrous.

The subtemporal decompression is purposely made in a situation away from the growth and is not only, I think, the most desirable procedure for cases of tumor which present no localizing symptoms, but during the past year the measure has been used as a preliminary operation for the temporary relief of severe pressure symptoms, even when the location of the growth is evident and gives promise of being accessible at a later operation.

On a few occasions it has been possible through such a preliminary subtemporal decompression to preserve the osteoplastic flap raised at the subsequent operation for removal of the growth. Had the osteoplastic exploration constituted the primary operation, closure of the scalp would have been impossible without removal of the bone, and large defects of this kind in unprotected areas (that is, other than subtemporal or suboccipital ones) are distinctly undesirable, even though, as Horsley has shown, aside from the deformity they may lead to no serious consequences.

I have stated on another occasion that no brain tumor may be so favorable for prompt operation as one which gives absolutely no clinical indications of its situation. Though difficult to make clear to many neurologists, the significance of this seemingly paradoxical statement is explicable in the light of some of our more recent experiences. For a number of years (the first subtemporal decompression was performed in September, 1903) these decompression operations have become a more or less routine measure in certain cases, until at the present time—taking the subtemporal operations alone—there have been about 100 all told, 60 of them for presumed supratentorial tumors. Though many of

these patients remain comparatively free from all symptoms of pressure, what is more important, others have returned after periods varying from one to three years with an onset of symptoms pointing at last toward the situation of the lesion, which in a number of instances has been successfully removed (Fig. 7).

In other words, the decompression in a safe area has usually so relieved the general pressure symptoms as to make patients subjectively comfortable and with their eyesight retained—a considerabe number of them indeed capable of earning their livelihood. Of the cases in which the growth has not been localized at the time of decompression, in some it has emerged, as it were, from its silent area and has shown focal symptoms; in others it has remained silent and in some instances indeed may even have metamorphosed into a cyst. Few of these patients would, I believe, have continued to live more than a few weeks or months, and some of them have passed from an actual bedridden state to active life again.

[At this point a number of lantern slides were shown, illustrating the steps of a subtemporal decompressive operation and of patients on whom the measure had been carried out, not only to relieve the increased tension of tumor but for other conditions associated with pressure, such as uremia and the cerebral edema accompanying basal fractures, cerebral arteriosclerosis, thrombosis and embolism of the cerebral vessels, etc.—Ed.]

LUMBAR PUNCTURE IN BRAIN TUMOR CASES.

A brain tumor usually, though not invariably, increases the cerebral tension, causing thereby the underlying pressure symptoms of headache, dizziness, nausea or vomiting, and choked disk. This increase of cerebral tension leads, as we have seen, to a greater or less protrusion of exposed cortex through any operative defect which may have been made in the cranium and pachymeninx (Figs. 9, 10, 11, and 12). As is well known, Nature occasionally succeeds in relieving the tension

made by a new growth—in the young through separation of the sutures, and occasionally in adult life, if the growth is a superficial one, by an area of pressure absorption.[10]

Furthermore a greater or less protrusion is inevitable through the normal opening at the foramen magnum—a natural defect in the cranial chamber. As a result of this the brain stem with a surrounding fringe of cerebellum is crowded down into the spinal canal—a condition which is especially marked in the presence of a subtentorial growth; for the tentorium in a measure serves to protect the cerebellum and hind-brain from the pressure effects of supratentorial (cerebral) growths.

This protrusion of brain stem—an actual hernia cerebelli—is of the utmost importance in its relation to the performance of lumbar puncture. For it is undoubtedly due to the presence of such a hernia that withdrawal of fluid by the lumbar meninges, especially in cases of cerebellar tumor, has so often been attended with early fatality from respiratory failure, the continued pressure from above sufficing, on the withdrawal of the fluid support from below, to further wedge the bulb into the foramen in such a way as to cause pressure anemia of the vital medullary centers.

Not a few instances of disaster in consequence of lumbar puncture have been recorded in the literature, and six have come under my personal observation—three of them were fatalities in the medical wards after puncture in cases of unsuspected cerebellar lesion,[11] and three have ocurred in my own surgical experience (Figs.

10. It may be said that in most cases of increased pressure, minute herniæ occur at the situation of the arachnoidal villæ, those that I have seen being particularly abundant over the under surface of the temporal lobes. Dr. S. B. Wolback has demonstrated that these minute surface irregularities are actual herniæ of the cortex. Journ. of Med. Research, July, 1908.

11. One of these cases was pictured and reported in the Mütter Lecture for 1901 (Am. Jour. Med. Sci., September, 1902, 398). Quincke has since called attention to this same process as one of the dangers of indiscriminate lumbar puncture, ("Diseases of the Nervous System," edited by Church and translated from "Die Deutsche Klinik," D. Apleton & Co., 1908, p. 233).

9, 10, 11, 12, and 13). If the brain after such an accident be removed from the cranial chamber soon after death, and particularly if hardened in situ, it will show the imprint of the foraminal ring about the protrusion which has been tightly jammed into the opening.

In Figure 13 the mould of this cerebello-medullary hernia is well shown in the brain from a patient with multiple cerebral tuberculomata—a single large tubercle in the left cerebellum having been unsuspected. During the course of a subtemporal decompression, owing to the great tension of the dura, a lumbar puncture was performed before opening this membrane. The fluid, under great tension, spurted for a moment from the needle, but ceased to flow after about 4 c. c. had escaped, when respiration almost immediately ceased. Under artificial respiration the dura was quickly incised, and though for a few moments normal breathing was resumed it soon ceased and the heart continued to beat for three hours as an isolated organ, which doubtless could have been kept in action under artificial respiration for a period indefinitely longer.

This is far from a unique experience,[12] but it is cited here for the purpose of emphasizing the hazard of lumbar puncture which exists in the presence of increased subtentorial tension.

In tumors above the tentorium, however, the continuous withdrawal of fluid during the course of an operation for decompression or for extirpation of a growth often proves an invaluable aid, and since I first called attention to the practice[13] it has frequently been employed. Helpful as the measure is and without particular risk, I believe, in solid lesions or edemas increasing the tension of the hemispheres, the possibility of an unsuspected cerebellar growth should always be borne in mind and the puncture not made unless the dura is exposed and ready for immediate opening in case medullary symptoms supervene.

In suboccipital explorations, on the other hand, the puncture would often be as dangerous as it is unneces-

12. I have recorded another case with 24 hours of artificial respiration, in my Mütter lecture, loc. cit.
13. Technical Methods of Performing Certain Cranial Operations. Surg., Gyn. and Obstet., March, 1908, 237.

sary, for one of the most important steps of these operations, after incision of the dura low down near the removed margin of the foramen magnum, is to open the exposed posterior cysterna and thus allow the pent-up cerebrospinal fluid to escape from above. If this precaution is not carried out the cerebellar tension often causes the hemispheres to bulge through the first dural opening so markedly as to rupture the pia-arachnoid and thus to cause extravasations which of themselves, through edema, rapidly increase the tension already present.

THE PRINCIPLE OF OUTWARD DISLOCATION.

This leads me to speak of the principle of dislocation without injury of normal cerebral or cerebellar tissue during an exploration or in the approach to a surface lesion more or less difficult of access, of which cerebellopontine tumors may be taken as a type. The thorough evacuation of cerebrospinal fluid from the basal cysternæ as mentioned above is of great assistance, but more important still is the bilateral opening with wide exposure of both cerebellar hemispheres. Under these circumstances, when one hemisphere is pressed to the side the other dislocates outward, giving a free view of the lateral recess without contusion of the easily damaged cerebellar tissue and without the field being obscured through blood staining. The latter is inevitable when a portion of the hemisphere is removed in order to give access to a tumor situated in this freely accessible angle. With a unilateral opening an equally free exposure is dangerous, if not impossible, without excision of a portion of the cerebellum.

This same principle is applicable to growths difficult of access in other situations, and I have found that in certain cases a preliminary subtemporal craniectomy, made some weeks or months before, proves sufficient for purposes of dislocation at a subsequent extirpation. For the approach to basal tumors in or near the mid-

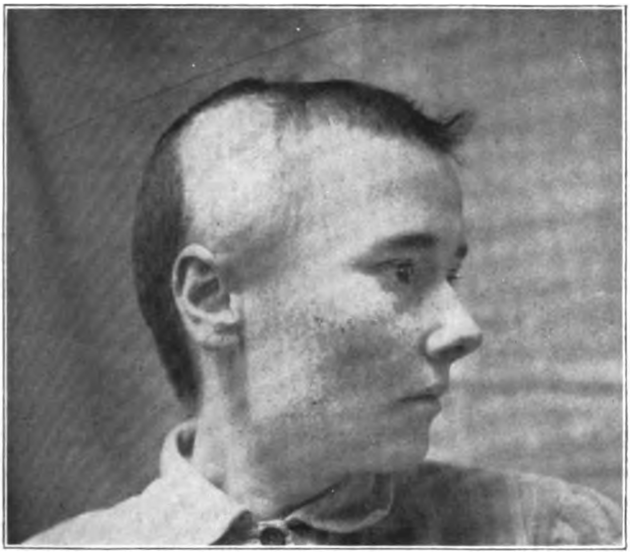
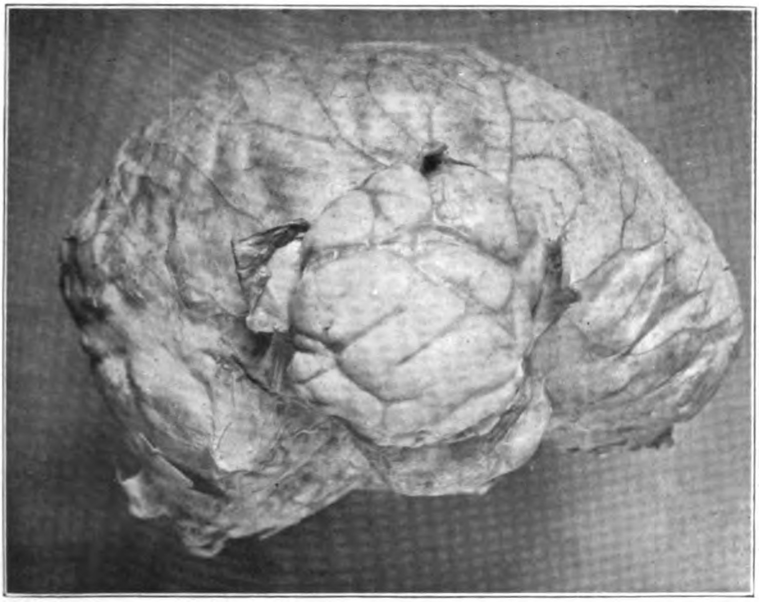


Fig. 7.—Patient with right subtemporal decompression, performed April, 1907, at a time when no recognizable focal symptoms were present. In May, 1908, a beginning loss of steriognostic perception in the left hand pointed to the position of the tumor in the right superior parietal lobe. It proved to be an encapsulated growth which was successfully removed. See Fig. 8.

Fig. 8.—Shows (above) the external surface of the tumor removed from patient, Fig. 7; and (below) the median section of the growth which is beginning to undergo central cystic degeneration. (Size slightly reduced.)



Figs. 9, 10. 11 and 12.—Photographs of the brain and its envelopes from a patient in whom a right subtemporal decompression had been performed for unlocalizable tumor. Symptoms not greatly relieved in consequence of unsuspected obstructive hydrocepalus. A month later a misguided lumbar puncture led to a promptly fatal issue. Note in Figs. 9, 10 and 11 the situation and extent of protrusion with complete absence of cortical adhesions; the hydrocephalus in Fig. 10; the tumor at A in Fig. 12, a right cerebellar glioma.

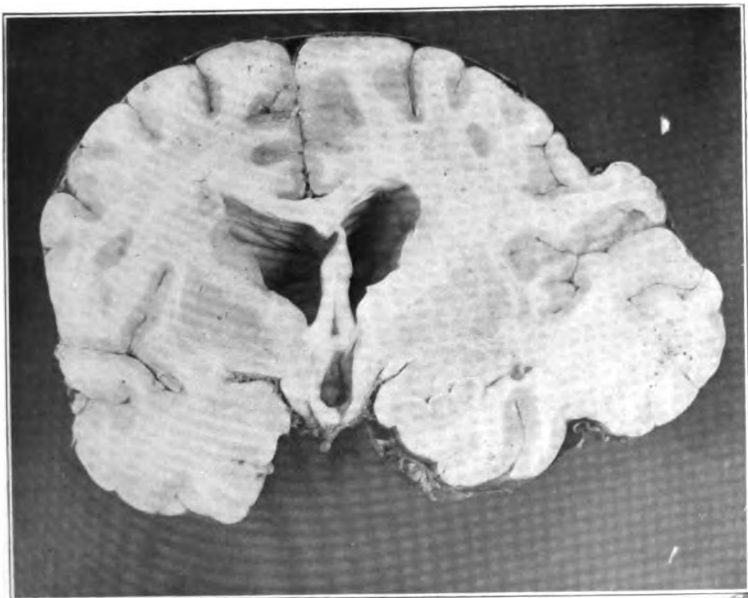


Fig. 10.—(Legend under Fig. 9.)

Fig. 11.—(Legend under Fig. 9.)

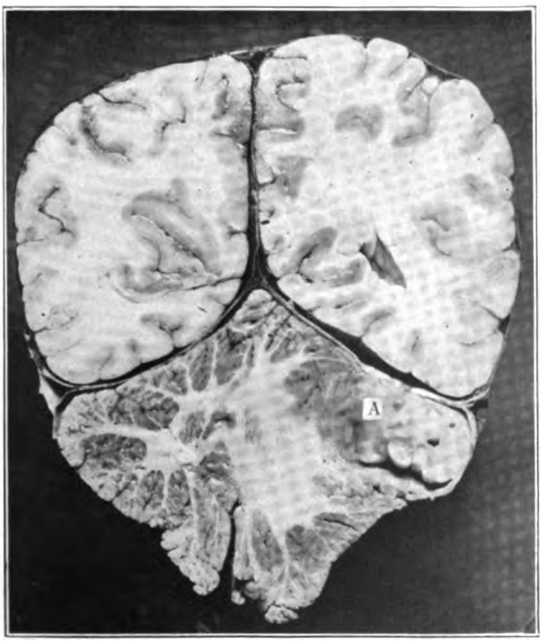


Fig. 12.—(Legend under Fig. 9.)

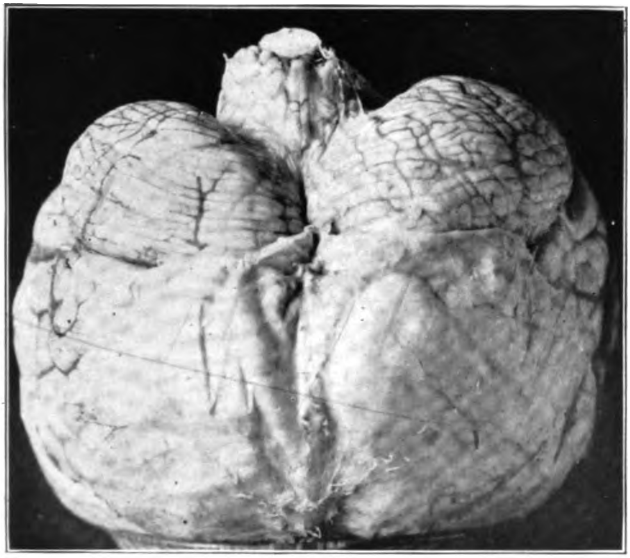


Fig. 13.—Photograph of posterior aspect of brain (inverted) in which multiple tuberculomas were present in the left hemisphere and cerebellum, and in which death resulted from lumbar puncture. Showing mould of cerebellomedullary hernia through foramen magnum.

Fig. 14.—Photograph of patient eight days after a Gasserian ganglion operation to show limits of incision, which are here clearly apparent; also partial shaving of head.

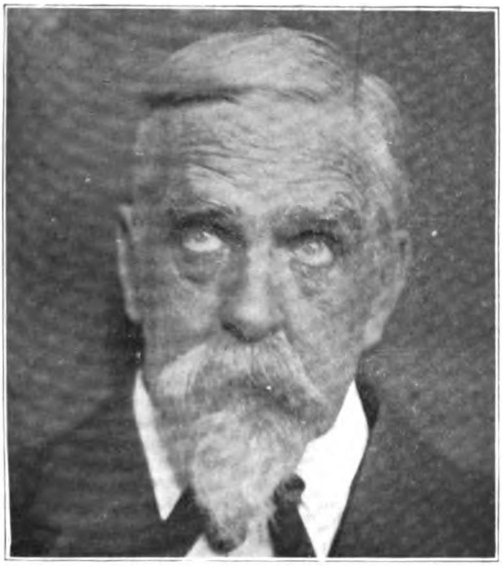


Fig. 15.—Same as Fig. 14, to show symmetrical wrinkling of brow and absence of other deforming consequences of the older operative methods.

Fig. 16.—Photograph of patient seven days after the Gasserian ganglion operation. Note the invisible wound; the partial shaving of the head; the preserved action of the occipito-frontalis muscle.

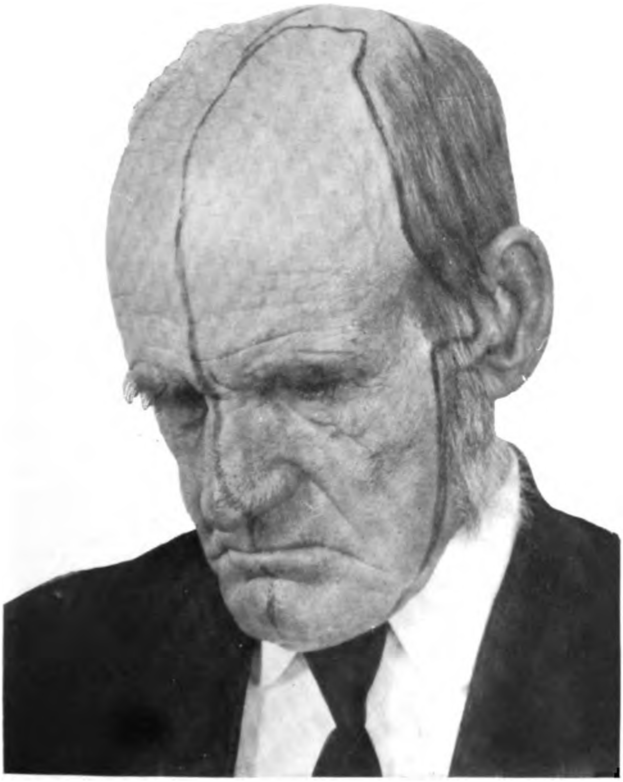


Fig. 17.—Showing persisting area of total anesthesia three years after a ganglion extirpation.

line I have occasionally made a large flap, with a wide dural opening, on the same side as that of the proposed exploration, and this has proved sufficient for thorough exposure in some cases, notably one of uncinate gyrus tumor and another of growth near the angular gyrus.

By applying this same principle I am confident that the best approach can be made to the pituitary body, though in these operations a bilateral opening is doubtless preferable—namely, a large exposure of the brain on the side opposite to that through which the pituitary fossa is to be exposed and a lesser cranial opening on the side of approach itself, with the smallest and lowest possible linear incision of dura. In this way the resistent membrane serves to protect the temporal lobe during its subsequent elevation, and through the large opening over the opposite hemisphere the brain readily dislocates outward in correspondence with the degree of elevation exerted during the approach to the hypophysis below the contralateral hemisphere.

Dr. Lewis L. Reford and I have found that this method of Paulesco's, with some minor modifications of our own, is a most ideal way of exposing the pituitary body, at least in dogs.[14] We have found too in corroboration of his experiments that the hypophysis is essential to life—a clean, simple, bloodless extirpation, if total, being followed by death in about 48 hours. To the loss of just what one of the three portions of the gland, which Schäfer and Herring have described, this is due, we are as yet unaware, but the knowledge is enough to call a halt for the time being in attempted hypophyseal extirpations for tumor. It is the case of the thyroid and myxedema, the parathyroid and tetany, over again.

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14. Technical experience with difficult procedures such as this (and I may include the ganglion operation) can be acquired in no way so satisfactorily as by practice on living animals. Although the mere anatomic relations must be learned on the human cadaver before the operaton can be transferred to man, nevertheless the experience of handling the central nervous tissues, of stopping bleeding from bone, membranes and brain, can be and should be acquired on the lower animals.

In some intracranial operations, however, the definite indications and necessary technical methods are well established—in no operation more definitely than that for trigeminal neuralgia of the major form. Here, although a certain amount of pressure against the temporal lobe is essential to a perfect exposure of the ganglion, this pressure is made against a brain not already under tension, as when a tumor is present, but against one susceptible of a certain amount of compression: hence in these operations the principle of dislocation need not be taken into account.

There is an element of danger, however, in too great pressure, and I think it can not be questioned but that the high temporal operation, so courageously originated some years ago by Hartley and Krause, entails more risk on this score than the more recent and lower methods of approach.

The degree of compression can be estimated if a careful chart of the pulse-rate be kept during the operation, for the vagus effect, shown by a retardation of pulse-rate, is proportionate to the degree of pressure-transmission against the medulla. In my earlier cases a pulse-rate as low as 60 per minute was not infrequent during the progress of the manipulations: this, however, has not occurred of late, doubtless through the experience gained in carrying out the enucleation through a very low and shallow opening.

Krause a year ago reported seven deaths in his series of 51 operations, and in all the fatal cases contusion of the temporal lobe was found postmortem—an evidence, I think, of the undue elevation necessitated by the high method of approach. I am able at the present time to report 74 ganglion operations, with only two deaths—both of the fatalities having occurred early in the series at a time when the effort was invariably made toward complete enucleation.

At present the procedure is greatly simplified by the avulsion from the pons of the sensory root alone, the ganglion being left in its bed with a half-inch gap between its posterior border and its original pontine attachment—a space which, even granting the possibility of central regeneration, could hardly be bridged by a new nerve. I think the method is preferable to the simple section of the nerve as proposed by Spiller and Frazier, not only for the reason given above, but also because it is possible to hook out the sensory foot intact, even in the many cases in which it is difficult or impossible to bring the structure sufficiently well into view to justify its actual division.

In the approach to the ganglion the incision (Fig. 14) should be so placed as to avoid (Fig. 15) the obtrusive droop of the brow which was an unavoidable consequence of the older methods owing to unilateral paralysis of the frontalis muscle. Similarly a careful closure of temporal muscle, fascia, and galea aponeurotica, can entirely prevent the objectionable flattening of the temporal region in consequence of atrophy of the muscle. Often the incision may be absolutely invisible a day or so after the sutures are removed (Fig. 16). The area of anesthesia remains permanent (Fig. 17); and the return of sensation to the forehead, or its retention there wholly or in part after the operation, indicates only a partial success and a possibility of return of pain in the ophthalmic division. There is no authentic case of recurrence of neuralgia after total extirpation or complete removal of the sensory root.

In all surgery I know of no more satisfactory measure than a successful ganglion operation nor of one which more certainly and more permanently relieves a larger measure of incapacitating pain. However, no one should attempt these operations who has not seen to the education of his own and his assisant's reflexes to the highest posible degree in the performance of every particular step by operations on animals and by constant

and repeated practice on the cadaver. Otherwise it is much safer for him to cling to the methods of temporary relief through peripheral operations, whether they be restricted to the injection into the nerves of mordants or to the removal of such of the branches as can be withdrawn without leaving the patient's face scarred—something the ganglion operation does not, or should not, do.

SUMMARY.

I have attempted to elucidate some matters in regard to a branch of surgery which in its present formative stage can only be safely undertaken with the best possible understanding of neurology. The few technical points which I have chosen to emphasize are:

1. The continuous auscultation of the heart-beat and respiration during anesthesia.

2. The subtemporal decompressive operation as an early measure and a step preliminary to a possible subsequent tumor extirpation.

3. The dangers of lumbar puncture in the presence of a degree of subtentorial pressure sufficient to produce a cerebello-medullary foraminal hernia.

4. The value of a continuous lumbar drain during the course of explorations for lesions of the hemispheres.

5. The principle of outward dislocation of normal tissue to avoid the risks of compression or mutilation during deep explorations.

6. The satisfaction of such intracranial procedures as the ganglion operation for trigeminal neuralgia when once they are put on a basis of comparative safety.

CRANIAL TECHNIC.

FRANK HARTLEY, M.D.
NEW YORK.

The most frequent causes of death following operations on the brain are shock and sepsis. Shock is given by Horsley as the cause in 8 per cent. of tumors diagnosed and removed and in 37 per cent. of those inaccurately diagnosed and not removed. Sepsis increases just in proportion as one is obliged to drain and is unable to heal by primary union; 30.8 per cent. of deaths is the usual proportion.

THE PRIME REQUISITES.

To avoid these dangers the following five requisites must be secured:

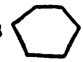
1. Instruments which will open the skull quickly over any desired area and to any extent. The preferred instruments are the motor, saw and guard, osteotome, drill, fraise and measure used by me.

2. A method of craniocerebral topography which will permit an accurate exposure of the intended cerebral area. It should be so accurate that the flap is neither too large nor too small. Chipault's is the best method, as it adapts itself to the skull of all ages, races or individual peculiarities.

3. Osteoplastic flaps cut so that they will expose the desired area in the easiest manner.

(a) For the lateral region the flaps radiate like the leaves of a fan, the broader part being toward the

vertex, the narrower extremity or hinge at the temporal fossa. These flaps are frontal, rolandic, parietal or occipital. They are four-sided as 

(b) For the exposure of both sides at once, bilateral flaps with their hinges in the temporal fossa, or single flaps with their hinges in the median line, are used. These flaps are either frontal, sagittal, occipital or occipito-cerebellar. The bilateral flaps are four-sided as  The single flaps are usually six-sided as 

4. The replacement of the bone flap in every possible case or the covering of the defect with an accurately fitting foreign material (celluloid or aluminum). I prefer autoplasty to heteroplasty because bone implanted when still in connection with its periosteum undergoes an immediate reparation if the circulation is not disturbed. Where the apposition is the most intimate, there one will find the least disturbance in healing, the slightest amount of bone absorption, and the surest safeguard against infection. Necroplasty is my second choice.

5. The assurance of a perfect hemostasis both in the preliminary as well as in the final steps of the operation.

These five points are to be mastered in any operation in which the cerebrum is exposed for the removal of a tumor, the draining of an abscess or cyst, or for the relief of an injury.

I would divide every operation into two steps, in which the preliminary step concerns only the skull, etc., and the final step, the cerebrum.

OPERATION—I. PRELIMINARY STEP.

All drugs are given up several days before operation.

A record of pulse rate and blood pressure is taken twenty-four hours before operation.

The patient's head is shaved twenty-four hours before

operation and Chipault's measurements made, recorded and marked with a fuchsin pencil on the scalp just before operation. Chloroform is preferred, though ether is often used where the head is raised more than 30 degrees.

The patient is placed on the table with the head of the table raised between 15 and 30 degrees. This position has been sufficient to stop the bleeding from the veins and to lower the arterial pressure. I have so far not been able to compare its value with the rubber suit and temporary compression of the common carotids (Crile) or with the sequestration-anemia proposed by Dawbarn. If either of these methods will improve the arterial pressure in greater amount than elevation alone, and with no greater danger of inducing sudden syncope, I shall certainly use them.

The sphygmomanometer is placed on the arm and blood pressure is recorded by the anesthetist. A sudden fall of blood pressure will warn the operator of an impending collapse. Horsley says that attention to this point will permit us to avoid the 25 per cent. of the sudden deaths following prolonged operations, and will force on us the necessity of two-stage operations.

The tourniquet is applied. I prefer one based on Lambotta's idea of a local anemia in the scalp. If this is not used, buttonhole stitches, Kredel's plates and the T-forceps of Chipault may be used.

The flaps are either four or six sided. Each limb is cut with a single stroke of knife. The periosteum is retracted on the bone surrounding the incision only.

A drill is applied to each angle (4 or 6 holes) and the depth of the holes is measured. If the disparity between holes is greater than 2 mm., that is, 3 or 4 mm., one or more holes should be interposed and measured. Thus it may be ascertained whether the incline between holes is gradual or abrupt. If gradual, the saw should be armed with guard for 2 mm. less than largest

measures and the bone divided with the saw at right angles to the bone-surface. If abrupt, the saw should be placed at an angle of 10 to 30 degrees to the bone, which diminishes the depth of the saw cut over the perpendicular cut about 2 mm. more. In this manner injury to the dura may be avoided without changing the guard even when the disparity between holes is as great as 4 to 5 mm. If one prefers, the guards may be changed, or two saws with different guards may be used. I always purpose to leave an uncut area of bone over the dura of at least 1 or 2 mm. If muscular tissue is very thick I use a fraise attached directly to the motor or by means of a short cable.

An osteotome (McEwens) is inserted into the slit, and with a few strokes of the mallet the bone (that is, the vitreous plate) is cracked. The point of inserting the osteotome is where the bone is the least divided. The bone is now lifted from the dura by 2 to 3 spud-like instruments, two of which are always placed near the desired line of breakage. When these are inserted a movement of depression to break the bone is made rapidly and with some force in order to snap this exactly between the two drill-holes.

Hemorrhage from the bone now requires attention. I make use of (*a*) Horsley's wax, consisting of vaselin 50, paraffin 50, and phenyl 5 parts; (*b*) decalcified bone plugs; (*c*) boiled wooden match-sticks; (*d*) cotton wool; (*e*) crushing forceps.

The reflected flap is protected by a towel and the dura mater is exposed.

II. FINAL STEP.

The condition of the dura is now noted: (a) its change in color; (b) its vascularity; (c) its thickenings; (d) its inflammatory changes, and (e) its pulsation or want of pulsation.

If the pulsation is wanting a tumor, pus or blood between the membranes, or severe contusion of the brain is suspected.

The dural flap is cut 1 cm. from the edge of the bone and on all but one side of the exposed area. This flap is lifted, and the tumor or disease is revealed immediately if it arises from the dura, the tentorium cerebelli or falx cerebri. The tumor or disease arising from this structure either pushes aside the convolutions and forms a bed for itself or it infiltrates the cortex or bone. The former is usually a fibroma, a syphiloma, a tuberculoma, or a traumatic or a hydatid cyst, while the latter is sarcomatous or the diffuse variety of tuberculosis or syphilis. If the process arises from the pia or cortex, the tumor or disease appears as (1) a vascular prominence surrounded with edematous brain tissue; (2) an encapsulated non-vascular mass; (3) a cyst containing serous or bloody fluid.

Growths of the first variety, among which are included angiomata and the racemose aneurisms, demand the most careful ligation of the vessels about their periphery before any attempt at enucleation is undertaken, as hemorrhage into the brain tissue favors infection (encephalitis) and destroys the tissue. Growths of the second variety (fibroma, tuberculoma, endothelioma) can be enucleated with a spatula if care is taken to avoid injury to the cortical tissue.

The cysts found here are congenital, traumatic, gliomatous or sarcomatous. So deceptive are the latter two varieties that the inner side of the whole extent of every cyst should be examined for tumor tissue. For the congenital cysts or those of unknown origin, long-continued drainage has been curative. For the traumatic and sarcomatous cysts, extirpation of the cyst wall is necessary. In the case of the latter, some brain tissue is usually sacrificed. These cysts are liable to be multiple and to have many prolongations, so that they must be followed

at times a great distance from the original area exposed.

Tumors or diseases situated in the subcortical area are located by puncture, if liquid; by palpation, with or without incision, if solid, or by electric stimulation. They are found at a distance of 1 to 6 cm. from the cortex, and the convolutions over them may or may not be flattened and the sulci effaced. The solid tumors are usually gliomata and sarcomata, while the liquid tumors are congenital, of unknown origin, or are classed as traumatic, porencephalic cysts. These cysts are curable by drainage alone, though extirpation, if advisable, would more surely cure them. Encapsulated solid growths are extirpated with resection of enough brain tissue to insure tamponade of the cavity and to avoid the possibility of recurrence.

Diffuse processes, tumors, scleroses and multiple hydatids are inoperable, except in so far as removal of a part may relieve symptoms of pressure. This can be done only when the hemorrhage is not liable to be great and where the lateral ventricles can be avoided.

During the second part of the operation two accidents are liable to occur, namely, hemorrhage and opening of the lateral ventricles.

Every vessel must be ligated carefully before cutting. This should be done in a delicate manner and without traction on the vessel in tying the knot. One knot is sufficient. Mosquito-forceps or a round needle, armed with a pliable ligature, is the best. Capillary hemorrhage is managed with moist gauze at 115 or 120 degrees applied to the area. Venous hemorrhage or oozing is treated by administering oxygen.

The longitudinal or transverse sinus or any large vein is closed by the total or lateral ligature or by suture. If hemorrhage can not be controlled in this manner, the best results have been obtained by tamponade and compression by the flap replaced.

The reason for careful hemostasis in this stage is (1) to limit the injury to the cerebral tissue by the blood infiltration; (2) to avoid the application of heat, and (3) to avoid the use of the tamponade. Careful hemostasis limits as well the danger of a late encephalomeningitis.

The second accident occurring during this stage is the opening of the lateral ventricles and the escape into them of the fluid washing, of the detritus of the tumor or of the brain tissue or of blood, which will form a nidus of infection. The mere opening of the ventricle, if one can see it at the time and avoid its infection by the admission of foreign material, is not dangerous.

If the operation has proceeded without accident and hemostasis is complete, the dura is sutured, the bone is replaced and the skin is sutured. A primary union is the rule. If the wound must be tamponaded or drained, the bone flap is either cut away to give exit to the tampon or drain, or the flap is replaced over the tampon for forty-eight to fifty-six hours and then is lifted, the tampon removed, and a small rubber drain or gauze substituted for it. After this the dural flap is sewn and the bone flap replaced and sutured except at exit of the drain.

POSSIBLE LATER COMPLICATIONS.

During the after-treatment certain accidents may take place: 1. Shock may be seen in prolonged operations with hemorrhage or after large tumors have been removed and the cerebral statics have been changed by the space left. In such conditions the acute cerebral edema of von Bergmann occurs. To avoid this, Horsley tampons and gives counter-pressure through the flap.

2. Hyperpyrexia: This occurs after both severe and moderate handling of the brain, especially if the ventricles have been opened. The cause is toxicity of the products of secretion of the neoplasm, infection itself or lesion or irritation of the thermal centers.

3. Encephalomeningitis may be caused by injury to the cerebral tissue or by infection from the patient's blood or from without. It is usually seen during the first month after operation, coming on slowly and announced by localized convulsions, contractures, paralyses, somnolence, mental torpor or delirium.

4. Hernia may be present at time of operation as a tumor of the base or as a voluminous tumor of the centrum ovale, or at a later period in the form of encephalitis.

OPERATIVE RESULTS.

1. *Operations on the Cerebrum.*—(*a*) Krause and Oppenheim[1] give statistics of 27 tumors of all kinds. Of the patients, 11 per cent. were cured, 22.2 per cent. improved and 55.5 per cent. died.

(*b*) Horsley[2] gives accounts of 55 tumors of all varieties. The regionary mortality was as follows: Motor zone, 3.7 per cent.; parietal zone, 5.26 per cent.; frontal zone, 7.69 per cent.; temporal zone, 8.3 per cent. The recurrence and mortality, according to tumor, disease, etc., were as follows: In glioma and sarcoma, 87.7 per cent.; in endothelioma, 12.5 per cent.; in tuberculoma, 50 per cent.; in gummata, none; in fibromata, none, and in cysts, none.

(*c*) Duret[3] reports 400 cases of all kinds, of which more than one-half were gliomata or sarcomata. The mortality was 19.5 per cent. The patients cured were 7 to 8 per cent.; those benefited by amelioration in the headache, vertigo, stupor, convulsions and paralyses, were 73.25 per cent. There was restoration of vision in 60 per cent. of the cases; partial restoration of vision in 28 per cent., and life was prolonged for several months in 33.5 per cent.

1. Wien. med. Wchnschr., 1906.
2. Lancet, 1906, viii, 52, and Jahrsbericht für Chirurgie No. XII, 1906, p. 402.
3. Tumeurs de l'encéphale.

(*d*) Alessandri[4] gives 22 cases of tuberculomata, in which 86.36 per cent. of the patients were cured.

(*e*) Duret[3] gives accounts of 33 cases of tuberculomata, in 69 per cent. of which cures were effected.

(*f*) Stransky[5] reports 18 cases of syphilis. In 15 cases the lesions were gummata. Of these patients 60 per cent. were cured or greatly improved; 40 per cent. were not benefited because the diagnosis was not accurate and the gumma not found or the process was too extensive. Of 3 patients with pachymeningitis, 33.3 per cent. were cured.

2. *Operations on the Cerebellum.*—(*a*) Horsley[2] gives the regionary mortality as 10 per cent.

(*b*) Alessandri[4] reports 6 cases of tuberculomata, in in which 33 per cent. of the patients were cured for 2½ to 10 months.

(*c*) Borchardt[6] gives accounts of 101 cases of glioma, sarcoma, etc. Of these patients 11.8 per cent. were cured; 16.8 per cent. improved; 11.8 per cent. died as the result of the operation, and in 59 per cent. of the cases the lesions were not found. He also gives 14 cases of cysts, in 92.8 per cent. of which cures were effected, and 21 cases of tuberculomata, in which 57 per cent. of the patients died of shock; 38 per cent. withstood the operation, of which 37 per cent. died of miliary tuberculosis, and 63 per cent. lived from 4 to 13 months.

(*d*) Stransky[5] reports 2 cases of gummata, with a mortality of 50 per cent. and 50 per cent. completely cured.

Cerebellopeduncular and Acoustic Nerve.—(*a*) Borchardt[6] reports 19 cases of fibromata. Of the patients, 15.5 per cent. were cured, 5.5 per cent. lived over one year, and 73.5 per cent. died. In 5.5 per cent. the fibroma was not found and not removed.

4. Ann. Surg. 1906, ii.
5. Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1906.
6. Arch. f. klin. Chir., lxxxi.

(*b*) Krause[7] gives 9 cases, with 66.6 per cent. of cures and a mortality of 33.3 per cent.

Pituitary Body.—Horsley[8] reports a mortality of 33.3 per cent., 66.6 per cent. cures from operations for adenoma and adenosarcoma.

From these statistics of cranial surgery the following conclusions may be drawn in regard to tumors. In glioma and sarcoma, recurrence and mortality is the same as in other regions of the body.

In regard to tuberculomata, statistics are as yet bad and uncertain in compilation. Surgery, when indicated, is better than serum therapy.

In syphilis, surgery is good enough to be tried after six weeks to three months of medicinal treatment.

Fibromata, non-malignant cysts and endotheliomata offer the best curative results and the slightest mortality. The endotheliomata recur in 12 per cent. of the cases.

The statistics on the operative treatment of meningitis lead to the following conclusions: Diffuse tuberculous and syphilitic meningitis offer no chance for surgery.

In circumscribed tuberculous and syphilitic meningitis Alessandri's and Stransky's statistics show a favorable percentage.

Circumscribed suppurative meningitis from trauma or extension from nose, throat or ear is curable.

In 10 cases out of 15 of otitic origin the patients were cured (Hinsberg[8]).

McEwen reports cures in 6 out of 12 cases.[9]

Amberger[10] and Witzel[11] report cures in 2 cases of traumatic origin, the one from a punctured wound of the cervical portion of the spinal canal, the other from a fracture of the base of the skull involving the temporal bone.

7. Arch. f. klin. Chir., lxxxi.
8. Ztschr. f. Ohrenh., 1906, No. 50, p. 261.
9. Infectious Diseases of Brain and Spinal Cord.
10. Beitr. z. klin. Chir., xlviii.
11. Verhandl. d. deutsch, Gesellsch. f. Chir., xxxiv.

Diffuse suppurative meningitis has been apparently cured by Poirier, Witzel[11] and Kümmel.

Surgical treatment demands a more extended application.

Statistics on encephalitis show that five patients were cured last year of traumatic encephalitis.

When symptoms of pressure exist and the disease or the tumor is not or can not be removed the operation for decompression is indicated for the following reasons:

1. It is an operation without danger.

2. The optic atrophy disappears in 6 to 8 weeks if operation is early, according to de Schweinitz.[12]

3. According to von Bergmann,[13] the patients in 65 per cent. of cases have shown amelioration of cephalalgia, stupor, vomiting, convulsions, paralysis and optic atrophy, for periods ranging from 1 month to 1½ years.

4. Borchardt[6] says that in "pseudotumors and meningitis serosa with hydrocephalus it has been curative."

The operation may be performed (a) in the right parietal region, according to Sänger,[14] (b) in the right parietal region with a 6x8 cm. removal of bone, according to Frazier,[15] (c) in the right temporal region with vertical incision on one or on both sides, if thought necessary, according to Cushing,[16] and (d) in the cerebellar region, according to Weisinger.[14]

In any case the dura may be excised, divided or left intact. Opinions are divided.

The rule is to operate where a tumor is suspected. If a diagnosis of location can not be made, select one of the three regions—temporal, parietal or cerebellar.

The time for operation is the beginning of optic atrophy.

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12. Univ. Penn. Med. Bull., 1906.
13. Traité de chirurgie cérébrale.
14. Zentralbl. f. Chir., 1906, No. 47, p. 1256.
15. Univ. Pennsylvania Bull., 1906.
16 Surg. Gynec. and Obst., 1905, No. 5.

No mention has been made in the paper of the operations on the cerebellum. This omission is purposely made, because I am not yet satisfied that the technic is what it ought to be nor have I anything to suggest which is any improvement on the methods already initiated by Horsley, Krause, Cushing, Frazier, Borchardt or Wiesinger. Thirty-two lantern slides were used to demonstrate the method of flap formation, etc.

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INTRACRANIAL COMPLICATIONS OF ACUTE AND CHRONIC MIDDLE-EAR SUPPURATION.

THEIR SYMPTOMATOLOGY, DIAGNOSIS AND TREATMENT.

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As I have several times written on one or more phases of this topic, I must ask your indulgence if I repeat statements that have already been presented in previous communications. The reason is obvious; first, because there is nothing new on the subject, and second, because the ground has been amply covered by many of our co-workers in this field during the past three or four years.

In discussing the intracranial complications of otitic origin, I shall place them in the order in which I have most frequently encountered them, which is as follows:

1. Pachymeningitis.
2. Epidural Abscess.
3. Thrombosis of the Sigmoid Sinus.
4. Meningitis of the Serous Type.
5. Thrombosis of the Jugular Bulb.
6. Thrombosis of the Internal Jugular Vein.
7. Brain Abscess, Middle and Anterior Fossa.
8. Cerebellar Abscess.
9. Meningitis of the Purulent Type.
10. Encephalitis.
11. Subdural Abscess.
12. Thrombosis of the Petrosal Sinuses.
13. Thrombosis of the Cavernous Sinuses.

PACHYMENINGITIS, KNOWN AS PACHYMENINGITIS EXTERNA.

Cause and Site.—This condition occurs usually as the result of a suppurative process extending from the mid-

dle ear and mastoid cells through the inner plate of the temporal bone. Its most frequent seat of occurrence in acute cases is the dura covering or adjacent to one or more portions of the lateral or sigmoid sinuses. Its second site in order of frequency is the dura covering the lateral surface and floor of the middle fossa; and in this region it is also the result of an acute process. The third common site, where the lesion occurs as a result of a chronic middle-ear suppuration, is in the region of the tegmen tympani.

Symptomatology.—The one prominent symptom complained of is headache, corresponding to the inflamed dura. This head pain is nearly always aggravated by exercise. There is extreme irritability of temper, and if a larger area of dura is involved, the patient exhibits twitching, drowsiness at times, intolerance of light, and in the severe type of cases, intermittent delirium, especially at night. Combined with these are the symptoms usually associated with the severe types of mastoiditis.

Diagnosis.—It is not often that the diagnosis is made prior to a mastoid operation, as, in the vast majority of cases in which a pachymeningitis exists, the lesion is not discovered until the operation on the mastoid bone is done. When it is suspected, it is because of the character of the pain, which is more severe and lasting than in uncomplicated cases of mastoid disease. When the disease is situated in the region of the tegmen, the pain is of a severer grade, lasting longer, radiating over a larger area, and the photophobia is more pronounced.

Treatment.—Every vestige of diseased bone adjacent to the inflammatory zone should be removed. If the bone is covered by firm granulations these should not be molested, as this is an attempt of nature to combat the disease. If, however, the area is covered with soft broken-down granulations, they should be curetted away and the parts rendered sterile by flushing with a warm saline solution, followed by absolute alcohol with a final saline flushing following the alcohol. A dressing of plain

sterile gauze moistened in a normal saline solution is placed loosely against the exposed dural area. In cases where a large dural space is exposed, the dressings should be changed frequently, as a wet dressing in contact with the dura is more comfortable than a dry one.

EPIDURAL ABSCESS.

Cause and Site.—This is a very common complication of mastoid disease. Its most frequent site is over and around the sigmoid sinus. When in this situation it is referred to as a peri-sinus abscess. Its site of next frequency is the region of the tegmen antri, and the abscess may extend all along the floor of the middle fossa. At times it is very extensive, extending posteriorly over a large area of the cerebellum.

Symptomatology.—In addition to the ordinary symptoms of involvement of the mastoid bone, the pain present is of a severer type, throbbing in character, and more persistent. The temperature during the disease is higher, there is more frequent vomiting, and all the symptoms usually present in a simple mastoid are aggravated to a marked degree. There is extreme restlessness at night, inability to sleep for any length of time on account of localized head pain, drowsiness, and in advanced cases, stupor. In many of the cases well-developed chills are present, with considerable fluctuation of temperature.

Diagnosis.—This is usually made at the time of the mastoid operation, although in well-developed cases it may be determined prior to the operation by the marked severity of the symptoms, the excessive degree of tenderness on pressure, and percussion over the accumulation of pus. A physical sign which aids in diagnosis, especially in cases of long standing, is the presence of swelling and edema of the soft parts externally, corresponding to the pus areas within. A differential blood count is of value, as here the proportion of polynuclear cells is higher than in an uncomplicated mastoiditis.

Treatment.—There can be but one successful method of treatment of this condition, and that is to remove all diseased bone adjacent to it; no matter how extensive it is or where it leads to, it should be removed, and the field of operation treated in the manner described under pachymeningitis.

THROMBOSIS OF THE LATERAL OR SIGMOID SINUS.

Cause and Site.—This complication is met by the otologist very frequently. It may be complete or partial, of the whole or of any part of the sinus or its adjacent blood currents, and may result from an acute or chronic suppuration of the middle ear. It is however, more frequently associated with a chronic purulent condition, or an exacerbation of such a condition. When complicating an acute middle-ear involvement, the infection is usually of a virulent type.

In reviewing the symptomatology, I shall follow my usual custom and speak of it from a clinical standpoint, under three separate headings. While not all cases can be definitely grouped under this classification, the majority can, and it is for this reason that I make the following clinical distinction. First, the typical cases; second, the atypical, and third, the cases in which the bulb and sinus are primarily involved without macroscopic disease of the mastoid process.

Symptomatology—Typical Case.—Temperature is one of the most important symptoms, and ranges from normal to 106 and higher, quickly followed by a remission to near the normal point or below. There may be one rise or several during twenty-four hours, depending upon the rapidity and the quantity with which the infection enters the general circulation. If the patient be kept under observation for several days, these exacerbations of temperature become more frequent and the variations greater.

Chills are present in about 50 per cent. of the cases, preceding the rise in temperature, and in well-advanced

cases followed by profuse sweating. Many patients exhibit no chill, and only complain of a chilly sensation, and this is frequently overlooked. In a postoperative mastoid case, with frequent variations of temperature, these chilly sensations are as important as though a distinct rigor were present.

When the temperature is high, there is a corresponding rapidity of the pulse-rate. Respiration remains unchanged except during the hyperpyrexia. Pain is more pronounced than when an uncomplicated mastoiditis exists and is referred to the occipital region. Where the internal jugular vein becomes infected early, there is pain along its course, due in all probability to an infected chain of lymph glands in that region.

Nausea and vomiting are usually present to a moderate degree during the stage of development, becoming more pronounced as the infection progresses.

Intraocular symptoms are present in about one-third of the cases. The earlier the patient is seen and operated on, the less frequently are they observed. If the infection has extended to the cavernous sinus, there is swelling and fulness of the eye and lid of the affected side.

Cerebration is normal except in advanced cases.

Among general symptoms are loss of appetite; dry, coated tongue, and dryness and yellowish tinge of skin, indicative of pronounced sepsis.

Physical Signs.—Edema is occasionally present over the mastoid region to a greater extent than in a simple uncomplicated bone involvement. In advanced cases there is marked stiffening of the muscles of the neck on the affected side, and the patient's head is drawn well over to the shoulder of this side. Combined with this, there is a well-marked rigidity of the muscles in this region. In a few cases where the vein is involved, it gives the impression of a hard cord-like swelling in the neck, but this physical sign is by no means so frequent as many of the text-books on this subject would have us believe.

Symptomatology—Atypical Case.—Atypical cases usually develop a few days after the mastoid operation. There is loss of appetite; the patient becomes restless and irritable; the tongue is dry with a thick coating in the center. There is a gradual increase in the pulse-rate from 100 to 130 per minute, and a slow but gradual rise in the temperature to 103 F, or 105 F, or higher; and this may remain so for several days. In many cases it will not vary a degree in twenty-four to forty-eight hours; in other cases there is a little more variation, but there are no sudden fluctuations. The patients complain of nausea and headache and are unable to sleep for any length of time. There is no chill or chilly sensation observed. There is marked irritability of temper; this is followed by drowsiness with sweating. The skin at first is dry, and later becomes yellow.

Physical Signs.—One of the signs which I consider of great value is, that the mastoid wound in the early stages of the disease is healthy and covered with granulations, except over the bone of the inner table which forms the sigmoid groove. This bony area is darker in color than it was at the time of the operation, and there are no granulations over any part of it. All the rest of the wound cavity shows evidence of healing. Should the infection progress, an entirely different condition will be found at the end of two or three days. The parts that before looked healthy will now look pale, and the granulations will have begun to soften and break down, while the bone overlying the sinus will be still dark in color, with no evidence of repair. If the sinus is exposed at the time of operation, the overlying dura appears grayish; there is an absence of luster, and often it is covered with a plastic exudate which is compressible if pressure is applied over it.

PRIMARY BULB THROMBOSIS.

This occurs usually in young children as a consequence of an acute purulent otitis, the result of a direct infec-

tion from the tympanic cavity through the floor of the tympanum to the jugular bulb. This explanation is logical if the fact is borne in mind that in a certain percentage of skulls of young children and adults, an unusually high dome is found encroaching on the middle-ear cavity; a dehiscence also not infrequently exists in this region. Under these conditions it can easily be comprehended how an active purulent infection of the middle-ear cavity can involve the blood current—finding its way through the small veins and lymphatics or by absorption through the parchment-like bone in this region, without first pursuing its usual course through the cellular structure of the mastoid bone.

Symptomatology.—Temperature rises rapidly from normal or thereabouts to 105 F or 106 F or higher, with a sudden remission to near the normal or below. It may remain below for several hours and then quickly rise to the high level, with as rapid a decline as before.

Pulse ranges from 110 to 160 or higher per minute, depending on the age of the patient.

Chills are not observed. Prior to the rise in temperature many of the patients have cold hands and feet; they are fretful, and extremely irritable and drowsy. The eye signs are negative. If this temperature range be permitted to go on for several days, these patients exhibit all the signs of a general sepsis. There is a phase of sinus disease in children and adults which should be carefully noted because it is so misleading and so frequently causes the postponement of an absolutely necessary operation. I refer to that period of the disease which is seen in a majority of cases during the temperature remissions, for at this stage I have often been misled by the patient's apparent improvement. During my earlier years of observation it was most difficult, and at times impossible to understand why, if the patient was suffering from such a serious condition, he should feel so well between the rises of temperature. A closer study of the cases, however, taught me that the rise in tem-

perature could be explained on the theory that some of the infective material from the sinus was being thrown into the general circulation by way of the internal jugular vein, causing a general systemic poisoning. When this occurred, the chill, temperature, nausea, vomiting and drowsiness were observed; but as soon as the major portion of the toxins had been eliminated the patients felt better; there was a subsidence of all former symptoms until sufficient toxic material from the seat of the thrombus was again disseminated throughout the general circulation. If such a case be allowed to progress without surgical interference these symptoms recur with greater and greater frequency until operative measures would be useless to save life.

DIAGNOSIS.

In typical cases it is based on the temperature changes, with the chill or chilly sensation preceding the rise in temperature following the mastoid operation. In many of the cases most of the symptoms given under Symptomatology are present, and when these occur a diagnosis is comparatively easy. In cases in which the sinus is operated on at the time the mastoid operation is done, and there are no previous symptoms as a guide, the diagnosis is based largely on physical signs; the dura is lusterless, thicker than usual and of a grayish or yellowish color, with frequently an adherent plastic exudate. The dura itself looks flat; does not present an oval appearance; is easily compressible, and does not fill quickly when pressure is removed. The mere presence of an epidural and a perisinus abscess is by no means an indication for exploring this channel, and the same is true if the sinus wall is covered with granulations, for this is nature's effort to protect the structures beneath. Bacteriologic examinations of the discharge from the ear are of value, as certain forms of infection are prone to greater activity and involve adjacent blood currents more rapidly than

others. A further aid in diagnosis is the differential blood count, of which the important part to us is the polynuclear percentage, which, if it be 80 or over, is indicative of pus-absorption, while the leucocyte count merely gives information as to the patient's resistance to the disease. A still further aid can be obtained from the blood by cultures; the knowledge thus gained is very valuable, and at the same time positive evidence can be gained of the nature of the blood constituents. These blood cultures will, I believe, supplant in real value all other forms of examination as an aid in diagnosis.

In atypical cases the diagnosis is also made from the temperature changes, the patient's condition and the physical signs presenting. These cases develop several days after the mastoid has been operated on, and can best be described by briefly outlining a case during its development and course. Take a postoperative case following its usual course for several days, when anywhere from the fourth to the 10th day the patient is restless, his appetite poor, his tongue slightly coated, his pulse 90 to 100, his temperature 99.6 to 100.6 F. The next day the temperature is from one to two degrees higher, with no marked remissions; restlessness is more pronounced; the patient is irritable, and has anorexia; his tongue is dry at the edges, and the coating more pronounced than on the previous day; the pulse is 110 to 120 per minute; and the patient has general headache, and nausea, and is unable to sleep quietly. The day following, the temperature is 104 or higher, and the pulse 120 or 140 per minute, showing less tension. The headache is more pronounced, and the restlessness, irritability and sleeplessness are distinct symptoms. The tongue becomes brown and dry and has a glazed center. If allowed to progress for another day the temperature is 105 F or higher, pulse 140 to 150 per minute and weaker. The patient is drowsy and apathetic; as the infection progresses the temperature is practically stationary. The pulse becomes weaker, and the evidences

of a general pyemia are present. A physical sign which is of distinct value from a diagnostic standpoint is the condition of the inner table covering the thrombotic area. Instead of being white and of a normal color as when the mastoid was operated on, it will be found dark. This is a distinct evidence of disease beneath, the change in color being due to an obstructed venous circulation throughout the bone at this point. If the sinus was exposed at the time of the primary operation, the dura covering it will be found to have undergone a marked pathologic change. It now presents a grayish or yellowish appearance, is flat and covered with fibrinous exudate.

PRIMARY BULB.

Diagnosis.—Here the diagnosis is made from the rapid temperature changes closely following an acute purulent involvement of the middle ear. The blood examinations are additional aids, and all other diseases should be ruled out by a process of elimination.

Treatment.—The time allotted me forbids any extensive description of technic so I shall speak only of the most important points, omitting all minor details. First, a complete and thorough exposure of the sinus from a point above the knee down to just above the bulb is essential. The treatment of the first and second class differ but little. Too much bone should not be removed posteriorly so as to expose a large dural area over the cerebellum, as a hernia is liable to occur in this region if this be done. The dura forming the anterior wall of the sinus should be incised freely, first with a scalpel to make an opening of sufficient size to allow of the introduction of a blunt pair of scissors. On exposure of the clot it should be removed; if no hemorrhage be obtained from the proximal end of the sinus, a further exposure toward the torcular should be made, and this should be continued until a free hemorrhage is established and it is certain that all infective material in this region has been removed. When this is accomplished

the blood should be allowed to flow for a second or two so as to wash out any clot or septic material that may be present further back in the vessel. The blood flow is then controlled by placing a piece of gauze firmly against the opening in the sinus. The lower portion of the sinus is treated in the same manner. If there is a free hemorrhage below, and the clot shows no evidence of having broken down, and pus is absent, the operation can be ended here and gauze packed into the lumen of the sinus. But if, on exposing the interior of the sinus, pus or a broken-down or disintegrated clot be found, or the operator is unable by gentle manipulation to restore the return circulation in the bulb region, he should without delay—and before any attempt has been made to remove the septic material in the sinus—expose, ligate and resect the internal jugular vein from the clavicle to its exit from the skull, together with any of its tributaries that are found involved, as well as infected glands along its course, and then proceed to evacuate the contents of the sinus above. In cases in which operation is done before marked systemic symptoms have developed, and before the coats of the vein below have become infected with the micro-organism of the disease, and where a return flow of blood in the bulb region is not obtained, it is not always wise to remove the vein at this time, for experience teaches that a certain number of these patients recover without further operative procedure. Should they, however, show evidence that a septic process is still continuing, the vein should be removed without delay, provided that the patient's condition will admit of it. In cases in which a return flow of blood has been established at the bulb, one is never sure from what source the current has its origin—whether from the internal jugular vein, or from the inferior petrosal sinus, or both. In a number of cases in which the vein has been removed as a primary step in the operation, before the sinus has been exposed above,

we find on opening the sinus that the return flow of blood from the bulb region is quite as free as we would expect if we had the internal jugular vein intact and performing its usual function, the blood coming no doubt from the inferior petrosal sinus. I have seen this demonstrated several times when the internal jugular vein was ligated and resected as a preliminary to exploring the sinus above.

THROMBOSIS OF THE INTERNAL JUGULAR VEIN.

Cause.—In otitic disease this thrombosis is always secondary to bulb or sinus involvement.

Symptomatology.—Occurring as it does secondary to sinus involvement, thrombosis of the internal jugular vein usually presents the symptoms associated with this condition. In a number of cases there is also pain referred along the course of the vein in the neck and radiating down over the chest of the affected side.

Physical Signs.—In some cases there is marked tenderness on pressure along the course of the vein and for some distance anterior and posterior to it, with perceptible fulness and swelling of the neck. In a few cases a hard cordlike mass can be felt, which, however, I have seen only once, and that was in a case of long-standing disease of the vein, with marked hypertrophy of the muscular coat.

Diagnosis.—This is usually made from the symptoms associated with disease of the sinus or bulb above and the physical signs, together with blood examinations and culture.

Treatment.—This consists of ligation, excision and removal, with any tributaries, and infected glands. The treatment of the resultant wound is optional either by the open method or suturing at the time of operation and inserting a large cigarette drain. I prefer the latter method, with moist saline dressings changed every twenty-four hours.

PRIMARY THROMBOSIS OF BULB.

As nearly all these cases occur in young children, and are produced by a primary infection of the blood current, the patients should be operated on early. When this is done the percentage of recoveries is in favor of removing the clot without ligating the vein, as they do not bear prolonged operations well. Later, if it becomes necessary to resect the vein, it can be done at a second sitting, without the added risk of a long operation. Not infrequently in this disease an exception must be taken to this conservative plan of treatment when, on opening the sinus, pus or a broken-down clot is found. When this condition confronts the operator, whether there be a free hemorrhage at the bulb or not, I believe that it is imperative for the safety of the patient that the vein be removed at once. Occasionally, a case of postoperative mastoid exhibiting all the typical signs of a sinus infection, is met. When, however, the sinus is explored, no clot or foci can be demonstrated; but as soon as the sinus is opened and a free hemorrhage occurs, the patient improves and recovery follows. I believe the explanation of this to be that there is a small parietal or central thrombus present, and the sudden gush of blood outward when the sinus is opened carries the clot with it, thereby relieving the vessel of any further infection. Before leaving this subject I wish to make a plea for early operation in these cases of infected sinus disease. Experience has taught me that the so-called elective time is during the temperature remissions, as the patients bear the shock of the operation better and react more favorably than if it is done when the temperature is at its height.

BRAIN ABSCESS.

Cause.—When we are confronted with the fact that about 37 per cent. of all cases of brain abscesses are the result of an extension of an infective process from the middle ear, it is not difficult to understand how impor-

tant it is to treat this local condition in order that adjacent structures may not become involved.

This otitic complication is very often difficult of recognition, because of the number of symptoms that may be present, some of which may be due to other intracranial conditions. For this reason a positive diagnosis prior to operation is impossible in many cases.

Symptoms.—In abscess of the middle and anterior fossa, the symptoms present in cases seen by me are as follows: A purulent discharge or the history of such, from the ear of the affected side; persistent and localized pain over the suspected area; tenderness on percussion; fretfulness; irritability; moaning, gritting of teeth and crying out in sleep; nausea and vomiting; insomnia at first, later drowsiness; photophobia; aphasia; depending on the location of the abscess; and vertigo in the majority of cases. Intraocular changes, when present, are valuable aids, but not positive. Nerve manifestations are of but little value in the majority of cases. The pulse, in cases uncomplicated by other intracranial affections, is slow, from 45 to 65; when complicated, it is much higher. The temperature ranges from subnormal to a little over 100; if coincident with other lesions it is much higher.

Diagnosis.—The diagnosis is made from several or all of the symptoms given. A differential blood count is of aid, and if the abscess be of the acute type, before a limiting membrane has had sufficient time to become organized, the absorption will be greater, and with this there will be a higher polynuclear percentage, ranging from 85 per cent. to 95 per cent. If the abscess be of the chronic variety, from an old middle-ear infection and of long standing, the percentage will be much lower, because of the small amount of systemic absorption taking place, and because the abscess walls are formed by a more or less dense and limiting membrane. A radiograph of the cranial contents may be of aid; in one case it has been of value to me.

CEREBELLAR ABSCESS.

Cause.—A collection of pus in the cerebellum may remain unrecognized for years, and if the accumulation be small in amount, with well-defined walls, give but little trouble; but if situated deeply, the lack of coordination on the part of the patient leads us to suspect a lesion of the posterior fossa. An abscess of recent origin may present many of the same symptoms as when located in other parts of the brain.

Treatment.—When the various regions of the brain are being explored for an abscess. the skull should be entered at a point corresponding as nearly as possible to the floor of the lobe about to be exposed, in order that free drainage may be obtained. There should be a sufficient opening of both the bone and the dura to enable the operator to examine the region in every direction. Many times the otologist is at fault here and subject to just criticism from the general surgeon, because he makes too small an opening in the skull, and produces more injury to the dura and cerebral substance than he would if he had a larger space to work in. After incision of the dura in a horizontal plane, it has been my custom to introduce silk sutures through the flaps, as in this way they can be used as retractors to draw the edges apart, while they do not injure the dura; should exploration prove negative, they can then be used to close the opening. In exploring the cerebral substance for a pus collection, experience has led me to rely on the use of a long narrow scalpel, and if pus be encountered, to withdraw the knife and introduce into the opening a pair of closed forceps, enlarging the opening by separating the handles. The cavity may be cleaned by one or two methods, depending on whether one is dealing with a pus accumulation of a recent or remote origin. If the abscess be of the acute type, without the presence of an organized tissue wall, the less manipulation used the better. It can be cleansed by gentle mopping with strips of sterile gauze, and drained by placing a small wick

of sterile gauze down to the bottom of the cavity, allow- and the brain substance to collapse around it; for it is a clinical fact that brain abscesses of the acute form discharge but little after evacuation and do not need firm packing. If the abscess be a chronic one, and if, in addition to the pus there be broken-down and disintegrated brain substance, it can best be removed by irrigation with a warm normal saline solution. The cavity should be mopped out with sterile gauze. In this type of abscess I have been accustomed to use for drainage purposes, a moistened wick of gauze rolled in equal parts of boric acid and iodoform; packing the whole abscess cavity quite firmly so as to promote repair; for with its limiting membrane or connective tissue wall, it does not collapse around a wick as does the acute type of abscess. A serviceable drain also in this latter type of cases, is decalcified turkey-bone. Before inserting the drain in any of these abscess cavities, the utmost care should be exercised in searching for multiple abscesses, as they occur frequently and are often overlooked, to be found at a subsequent operation or on autopsy.

MENINGITIS SEROSA, OR SEROUS MENINGITIS.

Cause.—This form of meningitis occurs not infrequently, as a complication of extensive mastoid or sinus involvement.

Symptoms.—Aside from the symptoms of the primary disease the one most prominent is pain referred to the basillar region, vertex of the skull and the cervical region of the spine. There is marked stiffness and rigidity of the muscles of the neck, and exquisite tenderness on pressure over the muscles, caused in all probability by the inflammatory process extending along the sheath of the spinal nerves from their exit at the skull. In a fair proportion of cases a chill is present. In well-developed cases the muscular tissue itself is swollen and tender to the touch. The temperature ranges from 99 F. to 103 F., always higher at night than in the morning. The

pulse rate is from 85 to 120. The respirations are unchanged at first, but later when pressure is pronounced they increase to 30 and 40 per minute. There is well-marked restlessness, moaning and irritability and hypersensitiveness during the early stage. Later this is succeeded by drowsiness; delirium occurs when the disease is well developed, and nausea and vomiting are present to a marked degree—depending on the amount of pressure exerted by the fluid.

Among the eye symptoms is congestion of disc. Photophobia is always present and nystagmus is frequent. A few patients exhibit difficulty in swallowing. The reflexes remain unchanged except in cases well advanced in the disease.

Diagnosis.—The diagnosis is made from the symptoms enumerated. An additional aid is lumbar puncture. When this is done the spinal fluid passes out through the trocar with distinct evidence of pressure and examinations and cultures of it demonstrate whether the case belongs to a serous or purulent type of the disease. If the fluid is clear and free from micro-organisms, then it is only the serous form. Differential blood count is of value.

Treatment.—Ice should be applied continuously to the head and neck; there should be free purgation; as little of sedatives as possible should be given to allay pain; the surroundings should be absolutely quiet; feedings should be frequent. Lumbar puncture is, I believe, of distinct therapeutic value, and large quantities of fluid can be drawn off with most beneficial results. This procedure can be repeated several times should it become necessary. In nearly every case the acute symptoms subside following the withdrawal of the fluid. Under this treatment a majority of the patients usually recover.

PURULENT LEPTOMENINGITIS.

Cause.—This form of meningeal involvement is frequently encountered as a direct extension from the mid-

dle ear through the tegmen tympani, from the mastoid, sinus, pachymeningitis, encephalitis and brain abscess.

Symptoms.—Many of the symptoms as exhibited in the serous type of meningitis are present during the early stage. With these we have the presence or history of an otorrhea. The restlessness, irritability and general discomfort are more pronounced. Vomiting is more or less constant, and is independent of the taking of liquids or food. Vertigo is nearly always present. Pain is severe and constant, referred at first to the frontal region or vertex; later along the cervical portion of the spinal column and radiating outward to the muscles. There is well-marked tenderness on pressure in the posterior cervical triangle, and the soft tissue is at times swollen. Temperature is uniformly high, from 103.5 to 105.5, with no marked variations except in cases complicated by other lesions. Rigors precede the temperature rise, and occur from time to time during the course of the disease. There is marked muscular prostration with areas of anesthesia of various portions of the body. Reflexes are but slight, and later absent. Thirst is intense. A number of patients exhibit herpes of the lips, with a rash over the chin, neck and chest. Eyesight is defective in the majority of cases. Photophobia is marked; later nystagmus occurs. Examination of the eyes shows discs hyperemic, with a beginning distention of the veins; later a well-marked optic neuritis is seen. The respirations are but little increased at first; later they become rapid, loud and stertorous; then slower and intermittent. There is complete absence of cerebration and death in coma.

Diagnosis.—This is made from the symptoms present aided by lumbar puncture, and here the fluid drawn is turbid, flaky, and contains large numbers of diplococci or meningococci.

Treatment.—Nearly all these cases terminate fatally. The application of ice locally seems to make the patient

more comfortable. Lumbar puncture relieves, for a time, the pressure symptoms. The rational treatment would seem to be to expose and drain the infected area, and this should be done early, before a general infection of the meningeal structures has taken place, if any measure of success is to be obtained. I have had only one successful case, and here the drainage was done early at the time of the mastoid operation. It is interesting to note in this connection, the communication and suggestion advanced by Dr. Cushing, namely, that if repeated doses of urotropin be given to a patient suffering from purulent meningitis, the micro-organisms are rendered sterile. If this be proved, it would be an easy matter to introduce a solution of this drug through the trocar into the spinal canal, after drawing off the amount of fluid desired, and before the trocar has been withdrawn. I believe, however, that the future successful treatment lies in an early operation.

ENCEPHALITIS.

Cause.—I shall speak only of that form of encephalitis which the otologist meets following the infection of one or more of the sinuses, or after evacuation of a pus collection in the brain—the latter being the more frequent of the two. In this connection its causation is by an extension of the infection from the sinus or abscess cavity through the veins or lymphatics to the cerebral or cerebellar substance itself.

Symptoms.—Occurring as encephalitis does after an operation in this region, the first evidence is given by rigors with vomiting, and closely following this is a sharp and sudden rise of temperature from near the normal point to 104 or 105 or even 106 F., with a correspondingly rapid pulse rate. Pain is severe, and referred to the exact region of the infection. Later, all the symptoms referable to well-advanced cases of brain abscess may be present.

Diagnosis.—Inspection of the wound is usually sufficient, as here will be found necrotic and broken-down tissue. At first it is odorless, but later when pus forms the odor is pronounced.

Treatment.—The protruding mass should be incised with the scissors; an effort should be made to remove all the disintegrated area; and the cavity should be cauterized and filled with powdered boric acid. The tissue is prone to bulge, owing to a further disintegration, and quantities of it have to be removed at each dressing. Drainage seems of but little use in this connection, as the quantity of the bulging mass forces the drain out. A few patients recover with this treatment, but the prognosis in the majority is bad.

SUBDURAL ABSCESS.

Cause and Site.—The two usual sites for the occurrence of subdural abscess are beneath the dura, corresponding to the tegmen antri and the tegmen tympani. In the former locality it is caused by an extension of an infective process from the mastoid antrum, through the superior portion of the inner plate. In the second situation it occurs from an infective middle-ear process through the tegmen tympani. In either case there is a localized pachymeningitis at the point of perforation, and later a localized accumulation of pus beneath the dura, between it and the brain substance covered by the pia mater. If discovered and evacuated early, it does no harm to the brain tissue, except by pressure while *in situ.*

Symptoms.—These are much the same as in a well-developed pachymeningitis or an extensive epidural abscess. If the pus accumulation be large, additional evidence of localized intracranial pressure is exhibited.

Diagnosis.—This is seldom made prior to operation. The dura, on exposure at one of the points mentioned,

will be found thickened, darker in color and bulging into the opening.

Treatment.—Incision of the dura evacuation of the pus and drainage is all that is required. Nearly all the cases recover if operated on early, before complications occur.

THROMBOSIS OF THE PETROSAL SINUS.

Cause.—This usually occurs by an extension of a thrombotic area from some portion of the sigmoid sinus or jugular bulb. The inferior petrosal is the one found involved most frequently, and its source of infection is from the jugular bulb into which it empties anteriorly. The superior petrosal receives its infection from the descending limb of the sigmoid sinus a short distance below the bend or knee. Either one or both of these blood channels conveys the infection to the cavernous sinus, from which they carry the blood direct to the sigmoid and bulb.

Symptoms.—These are very similar to those found in the phlebitis of the sigmoid and jugular bulb.

Diagnosis.—This can only be made a certainty by exploration after operation on the sigmoid, bulb and vein, for here, if the evidence of pyemic infection persists as shown by the symptoms, the presumption is that one or both of these channels is involved. I believe that they are infected far more frequently than is supposed, for many cases show no abatement of the symptoms after obliteration of sinus and bulb and removal of vein. This continuance of symptoms is, I believe, due to an infective process in these sinuses.

Treatment.—The only rational treatment is a free exposure of the thrombotic area; evacuation of the sinus contents and packing, so as to obliterate the blood current. It is my belief that many times when a complete operation has been done on the sigmoid bulb and vein, an encephalitis of the cerebellum subsequently develops as the result of an infective process left in these sinuses.

THROMBOSIS OF THE CAVERNOUS SINUS.

Cause.—This is seldom, if ever, primary, and very frequently is bilateral, owing to an extension through the circular sinus.

Symptoms.—Occurring as this thrombosis does secondary to thrombosis in other blood currents, we may have many or all of the symptoms that are present in these cases. Pain is always pronounced. The condition is one accompanied by basilar meningitis and when present is associated with the symptoms produced by this lesion, besides the others.

Physical Signs.—These are edema of eyelids and root of nose and face on affected side, ptosis and strabismus. Vision is defective; exophthalmos, retinal hemorrhages and choked disc are present. Pharyngeal swelling, as well as that of the tonsils and larynx, is frequently seen.

Diagnosis.—This is made from the symptoms and physical signs presenting.

Treatment.—I do not know of any treatment that is successful.

A few cases have been reported as recovering with complete loss of vision. Day[1] reports such a case. The duration of the disease is usually a few days; occasionally a case may go on for weeks or months.

I have purposely omitted thrombosis of the vertebral, mastoid, anterior and posterior condyloid veins, as well as the marginal sinus, as they seldom, if ever, occur primarily, save possibly thrombosis of the mastoid vein; and when a primary infection of this does occur, the symptoms resulting from it are immediately overshadowed by those quickly produced from infection of the sigmoid.

I urge most strongly the importance of teaching the undergraduate in our medical colleges more about aural

1. Trans. Am. Laryngol. Rhinol and Otol. Soc., 1906.

disease, and particularly the gravity of a running ear, so that when this class of case presents itself to him for advice and treatment, appropriate measures may be instituted for its relief. It is mainly in this way that we may hope in the future to diminish and limit the intracranial complications of otitic disease.

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INTRACRANIAL LESIONS CONSECUTIVE TO NASAL AND ACCESSORY SINUS INFECTIONS.

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My friend, Dr. John McCoy, and I have made a search of the literature and find that but few rhinologists have had any experience with intracranial complications. No rhinologist has reported anywhere near the number of cases depending on nasal infections as compared with the number met in an otologic practice. It is only within the past few years, during the development of the modern radical surgery of diseases of the accessory sinuses, that the cranial complications have at all come to the notice of the rhinologist. Previous to this time such intracranial lesions as were diagnosed fell into the hands of the general surgeon for operative treatment.

That infection occasionally extends from the nares to the cranial contents is sadly brought to our notice. That these complications occur as frequently as they do in connection with suppurative lesions of the tympanum, mastoid and internal ear, present information would seem to deny. A vertical anteroposterior section of the head just to the left of the median line shows the wide area of the cranium exposed to possible infections as a result of suppurative inflammation of the frontal, ethmoid and sphenoid sinuses. The antra nowhere come in direct connection with the floor of the cranium, yet it is possible for an infection in the antrum to reach the cranial contents indirectly through either the orbit or the ethmoid.

The frontal sinus may be absent, or it may extend in a vertical direction three inches above the orbital arch. Again, there may be a horizontal prolongation partially or completely over the roof of the orbit, so that in the latter case a very large part of the floor of the anterior fossa of the cranium may be exposed to infection extending from a diseased frontal sinus. Let me call attention to the close juxtaposition along the floor of the cranium of the two areas occupied, respectively, by the right and left ethmoidal and sphenoidal sinuses. The importance of this can be appreciated only by the surgeon at the bedside, who, having reason to suspect an intracranial lesoin in cases of bilateral sinusitis, is called on to decide through which side the infection entered.

Infections of the nares may extend into and involve the cranial structures in three ways:

1. Through the blood vessels.
2. Through the lymphatics.
3. By necrosis and perforation of the bony walls of the frontal, ethmoid or sphenoid sinuses.

1. While the bulk of the venous blood from the nose and accessory sinuses returns to the heart through the external veins, there is a small amount that reaches the superior longitudinal sinus through the foramen cecum, thus making it possible for infective sinus thrombosis or general infection of the system to occur.

2. The general lymphatic drainage follows the same course as the venous. The perineural lymph spaces around the branches of the olfactory nerve are so arranged that it is easier to understand how infective meningitis may arise by infection along this route. Evidence is yearly increasing that leads investigators to believe that the micro-organisms inducing meningitis gain access to the cranial cavity in the large majority of cases through the ear, nares or nasopharynx. The exact paths, however, by which they traverse the latter two regions remain still to be determined.

3. Necrosis of the walls of the sinuses and direct in-

fection of the dura. In discussing this subject I shall consider the frontal, ethmoid and sphenoid sinuses individually.

FRONTAL SINUS.

It has fallen to my lot to see a great many cases of frontal sinusitis, both acute and chronic. Having operated in more than two hundred cases in such a way that every part of the cavity was explored, I have records of but three cases in which there was a necrosis of the posterior wall. In two of them there was a history of syphilis, and from the extensive destruction of bone I can not help thinking that it was a very important factor. In the third case there had been a previous operation at which also I am told there was a small perforation of the posterior wall. In most of the cases of chronic frontal sinusitis which I have seen no matter how extensive the change in the mucosa, the bone had been only slightly altered from the normal. Occasionally I have observed an ostitis of a proliferative type resulting in the thickening of the bone in ridges.

Necrosis with perforation of the inferior or orbital wall of the frontal sinus is quite common. It is most commonly associated with obstruction to the adequate drainage of pus through the nasofrontal canal. The perforation is more frequently nearer the nasal than the temporal portion of the upper lid. Structurally, portions of the inferior wall of the frontal sinus are thinner than the posterior and give way to the pressure. In cysts of the frontal sinus there may be extensive pressure and absorption of the wall. A few non-syphilitic cases have been reported in which the posterior wall of the frontal sinus has been perforated and, as complications, epidural abscesses, meningitis and brain abscesses have been found.

ETHMOID CELLS.

There are three pathologic processes found in the ethmoid cells: suppuration, polyp-formation and cysts.

In suppuration, when drainage through the normal openings into the nasal cavities is obstructed, necrosis and rupture may occur either through the superior wall, that is, the cribriform plate of the ethmoid, into the anterior fossa of the cranium or through the external or orbital wall into the cavity of the orbit. As a result of rupture into the cranial cavity, three processes have been observed: meningitis, epidural abscess and abscess of the brain. As a result of infection of the orbital contents there occurs an orbital cellulitis characterized by a marked edema of the upper and lower lids with exophthalmos. Secondary to the orbital cellulitis, and even possibly primary in the case of the rupture of the posterior ethmoid cells, thrombosis of the orbital veins may occur, which, traveling backward, involves the cavernous sinus on the same side. Involvement of the cavernous sinus is invariably associated with marked exophthalmos and edema of the lids. Owing to the communication of the cavernous sinus on one side with that of the opposite side through the circular sinus, it occasionally happens that a sinus thrombosis arising from infection of one orbit and cavernous sinus extends through the circular sinus to the opposite cavernous sinus resulting in exophthalmos of the opposite eye.

POLYP-FORMATION.

Polyp-formation within the ethmoid cells causes extreme distention of the cells, rupture of the bony walls and occasionally results in absorption of the superior wall or orbital wall of the ethmoid. As polyp-formation is usually accompanied by suppuration in these cells, the subsequent history of such perforation either into the cranial cavity or orbit as a result of a new and added infection to that which is already present produces the same pathologic conditions as described above in suppuration. Cystic formation within the ethmoid cells results in varying amounts of distention of the cells with absorption by pressure of the bony walls in various

directions, upward through the cribriform plate or externally toward the orbit. As the contents of these cysts are usually sterile, the symptoms depend entirely on pressure and displacements produced by the mass. It is quite common for these cysts to absorb the lacrimal bone and displace the contents of the orbit. In such cases a tumor may be seen and felt near or slightly above the inner canthus of the eye, displacing the globe externally and often downward. If the cyst projects through the posterior ethmoid cells into the rear of the orbit, protrusion of the eye or exophthalmos may result. There is seldom in cystic disease any edema of the eyelids as in the acute inflammatory cases. The cyst may become infected, rupture and then suddenly the symptoms that were enumerated in acute suppuration may supervene.

SPHENOID SINUS.

Two processes are found in this cavity, namely, suppuration and polyp-formation. As portions of the superior and outer wall of the sphenoid cavity are normally very thin usually, one can readily understand how obstruction to the outlet of a purulent secretion may cause rupture of the superior or outer wall. The conditions resulting from this rupture are meningitis, epidural abscess, brain abscess, sinus thrombosis, impairment of vision, even blindness and exophthalmos. The cavernous sinus passes along the lateral wall of the sphenoid sinus and is the one usually to be involved in cases of sinus thrombosis. When the circular sinus is involved the clot usually extends quickly into the cavernous sinus, and both the right and left cavernous sinuses are secondarily involved. The relation of the sphenoid sinus to the orbit makes it possible for an orbital cellulitis to develop in connection with suppuration of the sphenoid sinus, giving rise to the same conditions as described in connection with the ethmoid cells. Of the three sinuses, the frontal, ethmoid and sphenoid, it has been my experience that intracranial complications are

far more apt to result from disease of the ethmoid and sphenoid than of the frontal.

That the rhinologist is not entirely at fault in not being able to determine the source of infection in many cases with the present methods of examination is perfectly true. In the first place, the anterior fossa of the cranium and the cranial contents found therein are those first involved when the nares are the source of infection. In the cases of infection from the ear the cranial contents in the middle and posterior fossa are first involved. It is well known that far more severe and extensive lesions may be present in the anterior fossa without giving rise to sufficient symptoms to enable the physician to make a diagnosis than in the middle and posterior fossa of the cranium. The rhinologist again meets difficulties in his examination of the nose far greater than does the otologist in the aural examination.

Nearly every patient ignores a moderate amount of discharge from the nares, considering it a type of catarrh which is common to every one. Consequently inflammatory lesions of the accessory sinuses, accompanied by a moderate discharge but unaccompanied by pain, are frequently unheeded by the patient. On the other hand, a discharge from the auditory canal is cause for concern and the seeking of relief. Nasal examination of a patient in whom intracranial lesions are suspected is frequently most unsatisfactory to the examiner and the family physician. For example, a patient in whom there are symptoms of meningitis in the early stages seeks an opinion as to whether the infection originated in the nasal cavities. Should the disease have extended through the veins or lymphatics it is scarcely likely that the nasal examination will detect the fact. If there is no sign of any secretion either in the nose or nasopharynx, one may never be sure that the sinuses are not involved. It is not at all uncommon to have the secretion from the ethmoid and sphenoid sinuses retained and only periodically discharged into the nares or naso-

pharynx. Without the evidence of secretion or any undue bulging of any group of cells, suppuration may be present without being detected by nasal examination. There are many factors which make it difficult to make a thorough nasal examination, such as the presence of a badly deflected septum, polypi, etc., which render a satisfactory examination unusually difficult. If, on the other hand, pus be seen in both nasal cavities, it is extremely difficult at a single examination to determine the extent of the involvement of the frontal, ethmoid and sphenoid cavities. It is still more difficult to determine in bilateral cases whether the infection has extended to the cranial contents from the cells, blood vessels or lymphatics of the right or left side. Since the cells meet so nearly in the median line and the physician is without the aid of a focal symptom as in one ear, little if any help is to be derived from a consideration of the subjective symptoms of the patient. Likewise, when but one side of the nasal chamber is involved in the suppurative process, great difficulty is experienced to determine whether the infection of the cranial contents arose from the frontal, ethmoid or sphenoid sinuses. With such difficulties, then, before the rhinologist, there should be no surprise that greater progress has not been made by him up to the present time.

The intracranial complications consecutive to nasal infection are meningitis, epidural abscess, sinus thrombosis and brain abscess.

MENINGITIS.

It is unnnecessary to enter into the details of the varieties and symptoms of meningitis. I shall merely remark that there is an acute type, not only involving the brain, but extending to the spinal cord, which is nearly always fatal. These cases are such as are most frequently seen by men devoting themselves to internal medicine. The source of infection is rarely if ever discovered. I have frequently been called in to decide

whether the infection reached the meninges through the nares. Finding the patient in a mild delirium, the difficulties attending a thorough examination of the nares and accessory sinuses were much enhanced and my nasal examination has in nearly all cases been most unsatisfactory to me. I have never felt that I could conscientiously advise an operation in these acute cases, and death has usually occurred within two or three days.

There is another type of meningitis commonly described as serous meningitis in which the symptoms are less acute. In such cases, if disease of the accessory sinuses has been discovered and no other source of infection can be found I believe that we are justified in advising operative interference with the object of removing further infection, just as is done in cases of otitic meningitis.

A third class of meningitis, a more chronic or leptomeningitis, includes cases in which undoubted sinus disease has existed for some time. When all other source of infection has been excluded, I would again advise operation on the same ground as in the case of serous meningitis.

EPIDURAL ABSCESS.

An epidural abscess is usually discovered at the time of operation for chronic sinusitis. It gies rise to vague symptoms which are frequently associated with sinus disease independent of epidural abscess. Headache is perhaps the most common symptom associated with this condition, but headache is so frequent in some of the severe types of sinus disease that from it alone we can not make a diagnosis of epidural abscess. In one patient on whom I operated there was a perforation, about 2 cm. in diameter, of the posterior wall of the right frontal sinus with a mass of granulations and pus between the posterior table and dura. The headache in

this patient was so severe and at times the mentality was so confused that I told the surgeon and the family physician with whom I saw the case that I suspected an abscess of the brain. The patient was under observation for a period of about ten days before he would consent to operation. During the twenty-four hours before I operated the patient had three epileptiform seizures, one occurring during the night. There was no history of any such attacks previously. The patient was immediately sent to the hospital when the epidural abscess as above described was found, evacuated, and the patient made an excellent recovery.

SINUS THROMBOSIS.

Thrombosis of the cavernous and circular sinuses gives rise to marked eye symptoms, such as edema of the lids and exophthalmos. These cases are more frequently referred to the ophthalmologist than to the rhinologist and surgeon.

BRAIN ABSCESS.

The symptoms which lead one to suspect an abscess of the frontal lobe of the brain are persistent headache, slight elevation in the temperature, pulse slow, possibly choked disc and a blunted mental activity, as apparent delay in comprehending the questions asked and slow response. I believe that there is a field as yet insufficiently developed, namely, skiagraphy, by which we shall be able to determine abscesses of the brain. I do not pretend to say that every novice in the use of *x*-rays can make a plate which will show an abscess when it exists, but I do believe that, if an opportunity were given to a few of the experts in this line of work to skiagraph patients with brain abscess, the radiographer would soon learn the proper tube and time of exposure so that in many cases brain abscess might be accurately located by this method.

OPERATION.

The operative technic which has been most satisfactory to me in exploring the sinuses has been what is known as the ethmoidal route. Skin incision begins beneath the eyebrow at the supraorbital notch, is carried in a curved direction downward midway between the inner canthus of the eye and the dorsum of the nose, and terminates at the middle portion of the nasal bone. The periosteum is peeled forward and backward, the capsule of the orbit freed from its attachment to the inner wall of the orbit. With chisel, mallet and rongeur forceps the nasal process of the superior maxilla is cut away, opening at once into the anterior group of ethmoid cells. By following this back through the whole of the ethmoid labyrinth and opening and enlarging the sphenoid sinus one traverses and explores very thoroughly the region from which the majority of infections reach the cranial and orbital cavities. The operation is a bloody one and sould be performed only by one who has acquired the ability to reflect light into the cavity so as to see into the depths of the ethmoid and sphenoid regions. By this route one is working parallel with the floor of the cranium and is much less likely to perforate the floor than by the maxillary route which is advocated by some. This exposure enables one to remove the floor of the frontal sinus and by means of probe to explore the frontal sinus, and in that way to determine whether this cavity may be the seat of the trouble. If this is found to be the case, then a horizontal incision through the eyebrow with the elevation of the periosteum over the frontal bone and the removal of the entire anterior wall of the frontal sinus is indicated. As many of these patients are desperately ill, it is exceedingly important that whatever operative procedure is undertaken shall be terminated as quickly as possible. The shock of a short operation is much less than that of a long one. In my opinion, it has been advisable in

these cases not to attempt to do the most thorough operation that one does in chronic suppurative sinusitis without cranial complications, but to exenterate all the cells as quickly as possible, introduce iodoform gauze drainage through the opening, and leave the wound open without any attempt at suture. Should the patient recover from his acute symptoms, secondary suturing may be done in the course of a few days with but little more scar than if the wound had been closed at the time of operation.

53 West Fifty-sixth Street.

DISCUSSION

ON PAPERS OF DRS. CUSHING, HARTLEY, M'KERNON AND COAKLEY.

DR. JOHN B. MURPHY, Chicago: The important lesson all of these papers bring to us is that there is here a splendid field for excellent work, to be explored by trained hands, and that no other should attempt it. I wish to call attention to a few matters unconnected with the technic of these operations. The ligature is splendid for the control of hemorrhage. Ligation of the external carotid can be accomplished in a few seconds, and in one condition particularly this ligation has been neglected for a great many years at a great life cost, and that is hemorrhage from the middle meningeal artery. The general practitioner who does not do much surgery can ligate the external carotid artery the moment he notes the first symptoms of hemorrhage of the middle meningeal artery. These symptoms are so clear cut that the diagnosis can readily be made. You do not have to hesitate with the operation or do it under unfavorable conditions, because after ligation of the arteries you can do the operation when you can get the patient in a favorable condition for the removal or relief of the compression. In this connection I wish to show an instrument devised by Dr. Neff, which is arranged to fit itself to any depth of cranium. It is an ordinary revolving drill and can be directed in any line desired. It does fairly good work. There is no very satisfactory machine for cutting the cranium up to date that has fallen into my hands.

The small size of the flap has hampered operations of this kind. That was brought out by Drs. Cushing and Hartley, showing that you can have a large-sized flap, but you must not have a profuse hemorrhage, because that is the greatest danger of all of these operations. The next important thing referred to was the palpation and examination of the brain after the dura mater has been opened. The experienced hand frequently can locate an encapsulated tumor or cyst. The

only needle which should be used is the double needle which has a blunt probe end and an opening so that when it is withdrawn one-sixteenth of an inch the lumen of the needle is opened and the contents of the cyst can easily be withdrawn. By keeping the opening closed until the capsule is punctured it is easy to withdraw the fluid if any is present.

Another practical matter is the advantage of the peripheral central systems in drainage. In the infections with accumulations in the cerebrospinal tract you can avail yourself of the large central system or of the cerebellar system for the relief of pressure. The significance of the closure of the foramen of Majendie lies in the production of atrophy of the optic nerve; central hydrocephalus without peripheral hydrocephalus; if that continues optic atrophy always results and it persists because of the occlusion of the foramen of Majendie. This operation I performed in 1896, opening and establishing a communication between the central and peripheral systems. In the central compressions of the optic nerve it was found that the re-establishment of this opening will prevent atrophy of the optic nerve. I paid a very severe price recently in operating on a case of ependymal spina bifida with paralysis of the lower extremity. The foramen of Majendie unfortunately was closed. I noticed that the child had central accumulation in the ventricles, but I felt that the foramen of Majendie was open and I permitted the patient to return home. To my horror and surprise, within six weeks, I was notified that vision had entirely disappeared. There was a central accumulation and a complete atrophy before I was notified, when I could have easily—it is not a difficult operation—have resected a V-shaped piece of the velum.

Dr. Jansen, Berlin: Like Dr. Coakley, I have seen very few cases of cerebral complication. In my material of about 800 operations on accessory sinuses I saw three patients, on whom operation had not been done, with purulent meningitis, and about 6 cases of large extradural abscesses. Among them was one of severe progressive osteomyelitis. There was no case of brain abscess, and only one of a severe serous encephalomeningitis with unconsciousness, lasting several days. The result was recovery after a purulent focus in the posterior ethmoidal cells, near the optic foramen, had been emptied. When an operation is indicated on account of suppuration of the accessory sinuses, I have little fear of cerebral complications. This comes into consideration only when there is severe pain and other indications of retention of pus. I should like to call attention to the importance of serous meningitis and encephalomeningitis in their relation to purulent meningitis, and also to the fact that that purulent meningitis has been cured in a number of cases. Finally, I desire to call attention to the importance of the disturbances caused by cerebral complications affecting the vestibularis, appearing as disease of

the nerve, basis or central organ (Deiters' nucleus). The principal lesions to be taken into consideration are abscess of the cerebellum or tumor of the auditory nerve. The complication of tumor of the auditory nerve with purulent labyrinthitis is especially hard to diagnose. In several such cases, lumbar puncture showed pneumococci in the fluid. The postmortem in one case showed an inoperable tumor of the auditory nerve, which had destroyed the cerebellum as far as the fourth ventricle. Nystagmus varies according to whether the peripheral end organ, the nerve, or the central organ is attacked. In the affection of the end organ, nystagmus is directed toward the healthy side of the head. In my case of tumor of the auditory nerve and in several abscesses of the cerebellum, it was directed toward both sides, but it varied. In looking toward the diseased side, the excursions were very extensive but infrequent; but in looking toward the healthy side the movements were very quick and minute. These differences seem to me to be of value in the diagnosis of tumor of the auditory nerve and suppuration of the labyrinth.

Dr. V. J. Baccus, Chicago: Since asepsis in the cranial region is even more important than in the abdominal cavity, attempts have been made to secure a perfect aseptic isolation of the operative field. Long ago Fenger and Murphy, while operating on the head, isolated the field of operation by carrying the rest of the aseptic sheet over the anesthetizer. In the lantern-slide demonstration of operative technic on the skull shown here, no provision was made to isolate the head from the nose and mouth of the patient and the masks and hands of the anesthetizer. This can readily be accomplished by encircling the head with the aseptic sheet and resting it on vertical table supports. The next important factor in exploratory operation on the cranium is to make a large flap. The ligation of the external carotid as recommended by Dr. Murphy need not be applied to all cases of skull surgery, as a routine procedure. According to statistics, the majority of surgeons do not ligate the external carotid artery as a preliminary step. When there is a possibility of injury to the middle meningeal artery, as in operating for the removal of the Gasserian ganglion, it may be necessary to resort to ligation of the external carotid.

Dr. Robert F. Weir, New York: Those of you who have lived long enough will, perhaps, remember the birth of modern brain surgery. In 1875-80, thanks to the urgent encouragement of some of my friends in neurologic practice, I was led to enter on this field. It was not a long invasion, because it dawned on me early that I was attacking tumors of the brain, most of which were malignant or which were local manifestations of a severe general disorder, such as tuberculosis and cancer. I learned soon that I was doing a very dangerous operation, and that I could give the patient only a

comparatively short prolongation of life. It discouraged me, I admit. Also the results in connection with epilepsy were not very satisfactory as operations were then done. My zeal was not, however, quenched, and I entered on the work in another direction, such as entering the substance of the brain in cases of deep hemorrhages, or to expose by lifting up the brain en masse for traumatic hemorrhage at its base on one or both sides, or to remove large surfaces of bone for the purpose of reaching and draining a suppurative meningitis. The great discouragement, however, I met brought me to the termination of my "brain" career and my enthusiasm departed and led me to go in other surgical directions.

As the outcome of my short experience, running over five or six years, three things of value have remained up to the present time. These have been alluded to in the admirable papers presented here to-day. The first was the rubber band around the head. We tried many ways to stop the annoying hemorrhage from the scalp. The rubber band I first resorted to at the suggestion of Dr. M. Allen Starr and it proved of such value as to retain its place in surgery. The second thing was the use of celluloid plates to fill in defects in the skull where bone had been destroyed by earlier operations, such as by multiple trephining or by grooving or by chiseling. I resorted to the use of these plates, perforated or non-perforated, also in fractures as well as in the brain tumor operations. following the example of the German surgeon, Fraenkel, and found their use very satisfactory. In one instance I kept track for five years of a patient in whom it was inserted for a large opening in the skull and found no disturbance arising from its retention. Dr. Cushing has alluded to the outcome of our experience of two unsuccessful attempts to find the tumor after a cerebral exposure. We succeeded here to an unexpected degree, however, in relieving the patient of distressing symptoms and advised then that such a procedure should be carried out in subsequent cases, which has been done to a large extent in recent years.

Dr. Willy Meyer, New York: On the basis of personal experience I favor proceeding in the same way in the posterior fossa of the skull as in other parts of the skull, namely, by arranging for an easy access to the brain by a wide removal of bone—wider than is usually advocated. It has been advised that operation for tumor of the occipital region be done in two stages, also that access to it, especially to those tumors situated at the ponto-cerebellar angle, be gained by partial or total removal of the respective cerebellar hemisphere. This advice, it seems to me, should not be accepted without thorough discussion. A number of such operations in two stages are on record in which the patients died shortly after the bone operation had been completed, and the tumor was never exposed.

In the interest of asepsis, it seems to me, we should try to get through with the work in one sitting. Furthermore, it stands to reason that, if we can accomplish our aim with the cerebellum left intact, this must mean a gain to the patient.

With these points in view, and inspired by the excellent work of Cushing, Hartley and Frazier on this side of the Atlantic and of Krause abroad, I recently undertook an operation for tumor of the left auditory nerve in a girl, 27 years old. I do not think that osteoplastic operation can ever be done to advantage in this region, mainly on account of our inability to control hemorrhage properly, which, as is well known to those familiar with this kind of work, may prove alarming at times. (I would mention parenthetically that I have found Horsley's wax of great help in controlling hemorrhage in these cases.) Therefore, after having formed and turned down a large horseshoe-shaped skin-muscle-periosteal flap, and, according to Cushing, dividing it in the middle. I removed the entire occipital bone, first thinning it with a grooved chisel, then biting it with rongeur forceps. Of course, I carefully avoided the external occipital protuberance. The border of the foramen occipitale magnum was fully exposed. Then followed double ligature and division of the longitudinal sinus, heart-shaped incision of the dura mater and turning down of the flap. Now the entire cerebellum was before our eyes. With the help of a long brain spatula I reached the internal auditory foramen and, with the electric reflector, clearly saw the tumor, of the size of a small hickory nut, involving the auditory and facial nerves. This was bluntly removed. Acute edema of the brain prevented the proper return of the dura mater flap. The latter just sufficed to cover somewhat more than the lower half of the cerebellum. Injury to the exposed brain from the irregular, roughened occipital protuberance was carefully guarded against by gauze tamponade. The skin flap was sutured in place. The patient made a good recovery. Having been almost totally blind before operation, with staggering gait and all the other symptoms of brain tumor, she is now able to read almost the smallest print. Her gait is improving steadily; she has done some needlework within the last few weeks, and we may now hope that she will go on to complete recovery. This case shows that easy access to the cerebellum obtained by the removal of a large piece of bone enables us to avoid pressure injury to the medulla or pons and renders unnecessary the removal of portions of the cerebellar hemisphere.

Dr. Harvey Cushing, New York: Widely different operative methods have been advocated in this morning's session by the different speakers—methods which have the same end in view, namely, the most rapid way of entering the skull compatible with perfect safety. It goes to show partly that the individual needs of one operator are not necessarily those

of another, and partly that familiarity with a given set of instruments breeds facility in their use. After all, the best osteoplastic method of exploration is chiefly a matter of technical interest. What those of us who are interested in neurologic surgery are trying to do is not so much to perfect methods of rapidly laying bare the surface of the brain as to perfect our ability to diagnose a cerebral lesion and to evolve the proper methods of dealing with it when once the skull has been opened. We are only at the beginning of these matters, though strides forward are being made daily by the leaders in this work. It does not make any difference whether the bone flap is turned down by one method or another—provided, indeed, a bone flap is necessary, and often in fact it is not. It is what is to be done on the inside that is vital, and for this some knowledge of neurology is absolutely necessary; and that is the plea I wish to make to-day—the necessity of a neurologic training for those who wish to follow this particular kind of work.

Dr. Weir's contributions to this field of surgery made twenty years ago are well known to all who have made themselves familiar with the early literature of the new cerebral surgery; but I think that he is a little too optimistic about some of these present endeavors of ours, and Dr. Murphy's unbounded enthusiasm must not make us go too fast. Thus, his anticipation of twenty-five extirpations of the pituitary body within the next year, if they are "successful," or, in other words, total, means unquestionably twenty-five deaths in the twenty-five cases, for recent work has shown that the pituitary body—or I may say a portion of the pituitary body—is absolutely essential to life.

Dr. Frank Hartley, New York: Two things of importance for the next year are the production of instruments which can be used by every one and of a simpler means of stopping hemorrhage. The various saws and drills which are used now, and which are necessary to do rapid work, require a long period of tutelage in order to be able to use them safely. Therefore, I think that it would be a great advantage to have, in the first place, instruments which could be used by any one with perfect ease and safety. In the second place, I think that the thing which will advance cerebral surgery more than any other will be some simple method of stopping hemorrhage. As soon as we stop the hemorrhage, we diminish the shock; when we diminish the shock and stop the hemorrhage, we can spend a time in enucleating the growth from the cerebellum or cerebrum or whatever point we are trying to reach.

Dr. Charles H. Frazier, Philadelphia: I feel very much as Dr. Cushing does about the development of cranial surgery. We are just making a beginning again in this field, it seems to me, after the setback which the work received at the hands

of the German surgeons, notably von Bergmann, not many years ago. We have accomplished certain things, such as the development, I might almost say perfection, of the technic of exploratory operations for lesions anterior to the tentorium cerebelli, and the technic of operations on the Gasserian ganglion. As to operations for lesions posterior to the tentorium cerebelli the technic seems to me in many ways deficient. We have not, as Dr. Hartley pointed out, discovered a way of adequately controlling hemorrhage, and, no matter what efforts we make, hemorrhage may be so profuse as to become alarming in a few minutes after the operation has been begun.

We have heard nothing to-day of the two-stage feature of cranial operations, and I take it that it has been very largely abandoned, and, I think, properly so. By means of blood-pressure observations we can determine with reasonable accuracy the condition of the patient, and there is no reason why, once the tumor or lesion has been exposed, we should not at once proceed to its removal. The dangers of infection from reopening the wound and of a second anesthetization are so great as to make the two-stage operation absolutely unjustifiable. The decompressive operation has become so popular of late that there is a danger of its adoption in cases in which an exploratory operation is clearly indicated. Although decompression entails less risk to the patient, it is less difficult and requires less experience. When there is the least suspicion of the presence and location of a lesion, it is the surgeon's duty first to explore the region under suspicion; failing to find it, he may then conclude the operation with the removal of as much of the dura and bone as may be necessary to effect decompression. If this course is not adopted, many operable lesions will be overlooked and the percentage of absolute recoveries proportionately decreased.

Dr. C. G. Coakley, New York: I did not go into the matter of deaths following operation at all. I merely spoke of the cases of sinus disease which in the last few years were almost invariably fatal because no operation was done; but the tendency now is to operate and a certain proportion of these patients will recover that would have died.

MY PRESENT POSITION ON APPENDIX QUESTIONS,

AND REFERENCE TO THE DAWN OF THE FOURTH OR PHYSIOLOGIC ERA IN SURGERY.

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The time has arrived when we may, at least tentatively, classify four separate and distinct kinds of appendicitis: 1, Fibroid degeneration appendicitis; 2, infective appendicitis; 3, congestive appendicitis; 4, appendicitis by external invasion.

FIBROID DEGENERATION APPENDICITIS.

This is an irritative lesion rather than an infective one, and it seems to be the one, on the whole, which takes the largest number of patients to the physician.

It occurs during the course of normal involution of the vermiform appendix. In this process there is replacement of the various structures of the appendix by hyperplastic connective tissue. Nerve filaments persist for a longer time than most other structures in the appendix which is undergoing involution changes, and these nerve filaments are irritated by the contracting connective tissue in the same way as other nerve filaments are irritated in contracting connective tissue in other parts of the body—notably in the scars of amputated limbs. The effects of irritation of entrapped nerve filaments in the appendix seem to be of two chief kinds. Irritated sensory nerve filaments give rise to a sensation of discomfort in the appendix region. This is com-

monly little more than an indefinite feeling of discomfort, but it may amount to actual pain. Patients are apt to press on the abdomen with the hand over the appendix region, or to lean against a chair or table for relief. Irritated sympathetic nerve filaments entrapped in the contracting appendix seem to cause an excitation of the intima ganglia of the bowel wall (Auerbach's plexus and Meissner's plexus), and this leads to derangement of function of the secretory and excretory apparatus of the bowel, causing intractable intestinal dyspepsia.

According to my experience, fibroid degeneration of the appendix is the commonest single cause for intestinal dyspepsia. This probably does not often merge into infective appendicitis for two reasons: First, the structures involved in infective appendicitis are actually removed through connective tissue replacement; second, the chronic irritation calls out chronic leucocyte protection, so that the patient suffering from fibroid degeneration of the appendix seems to be specially guarded against infective invasions.

Diagnosis of Fibroid Degeneration.—There are five important diagnostic points for recognizing fibroid degeneration appendicitis:

1. Hyperesthesia of the right group of lumbar ganglia, when deep pressure is made at a point about one inch and a half to the right of the navel.

2. Constant presence of gas in the cecum and ascending colon to the hepatic flexure.

3. Intractable intestinal dyspepsia.

4. Persistent discomfort, varying in degree, in the appendix region.

5. An appendix which feels harder than the normal appendix on palpation.

The condition of fibroid degeneration of the appendix causes disturbance for many years, but is seldom noted in patients less than 20 years of age. It belongs to middle and later life. It is well understood by a few diagnos-

ticians, but has been overlooked in most of the patients whom I examine. So little is the condition recognized as yet that surgeons operating in cases diagnosed as chronic appendicitis have sometimes closed the abdomen without removing the "inconsequent appendix" which was found, believing that they had made a mistake in diagnosis. Other surgeons removing such appendices on general principles, but still believing that they had been mistaken in diagnosis have been surprised at the prompt and unaccountable recovery of the patient's health.

Patients do not often go to bed with the irritative lesion of fibroid degeneration of the appendix. They are the patients who go the rounds of the profession asking for definite diagnosis in connection with their appendix symptoms or for their intestinal dyspepsia. Blake has described a series of cases corresponding closely with these cases of fibroid degeneration of the appendix, but he ascribes the symptoms to faulty mesenteric attachment. I believe that his specimens were not subjected to microscopic examination, and that another series of specimens, examined with reference to fibroid degeneration, will be found to contain many belonging to the latter class rather than to the class in which faulty mesenteric attachment leads to mucous inclusion or to vascular derangements.

Treatment of Fibroid Degeneration.—My position relative to operation in these cases of fibroid degeneration is to advise against it when the patient is first seen. He is asked to follow medical treatment under the care of his physician. Many of the patients, relieved of their fears of appendicitis, become so well that they need little further attention. Other patients will return at the end of a few months and ask to have the fibroid degenerating appendix removed.

On account of my interest in the subject, some of my assistants at the hospital, for the sake of brevity, got to calling these cases "cases of Morris' appendix." The

nomenclature is not allowable for two reasons. Senn described them in a general way as cases of "appendicitis obliterans," and Ribbert referred to the condition as "normal involution of the appendix" before I took up the study and noted the presence of persistent nerve filaments and observed the occurrence of hyperesthesia of the right group of lumbar ganglia as a diagnostic point. If for the sake of brevity it is desirable to call cases of fibroid degeneration of the appendix by the name of any observer, they should be called Senn or Ribbert appendices.

Another reason why the nomenclature of "Morris' appendix" is undesirable is because the appellation has gone wrong in some quarters and now stands for the perfectly normal appendix. This began apparently in a spirit of humor, but by *reductio ad absurdum* on the part of serious men it led to the conclusion that I favored removal of the normal appendix. As a matter of fact, I have always opposed the idea of removal of the normal appendix, even when it appears incidentally in the course of some other operation. My reason for this is that the field about the normal appendix is unprotected by leucocytosis, and the opening of ever so small a part of the intestinal lumen in an unprotected field calls for a great degree of skill.

A type of appendix which may be confused with the fibroid degeneration appendix is the fibrous scarred appendix remaining after infective invasion. The history of acute infective invasion, and the destruction of nerve filaments along with other structures in such an appendix will commonly serve for making the distinction.

INFECTIVE APPENDICITIS.

At present infective appendicitis is the most conspicuous ailment of the appendix, even though numerically the cases seem to take second place. My position in regard to causation of this type of appendicitis has

not changed since the publication of my book on the subject in 1895. This work is now out of date on many other points. I believe the common, acute, infective appendicitis to be due to anything which causes the inner soft coats of the appendix to swell to the point of strangulation within the tight outer sheath. It matters not whether this swelling is caused by the presence of a concretion, the extension of an ordinary colitis, a blow or a twist from the psoas muscle, or any one of a number of disturbances.

As soon as the lymphoid, mucous and submucous coats have swollen within the tight sheath of muscularis and peritoneum they become anemic (compression anemia). An isolated anemic area of this sort should be instantly attacked by bacteria, for the reason that it has momentarily lost its leucocyte protection, and because the bowel bacteria of the lumen of the appendix are right at hand to begin invasion into such an anemic area. The infective process is brought to a halt in one of three ways: 1, By sufficient determination of phagocytes to the point, through blood vessels not disabled entirely; 2, by sufficient determination of phagocytes to the point of blood vessels in neighboring structures which have become adherent to the infected appendix; 3, by surgical removal of the appendix.

WHEN TO OPERATE.

It is evident that without surgical operation the infective invasion is confined only by the limitations set by the autoprotective factors of the individual patient. By this we mean his ability to manufacture opsonins and phagocytes, and to get them to the field of action through unobstructed blood channels. On the basis of this belief I still hold to the dictum, stated many years ago and which aroused considerable antagonism, to the effect that in acute progressing infective appendicitis operation must be performed as soon as the diagnosis is

made. The reason for this is that the bacteria are performing an operation on the appendix, and operation by the surgeon is merely a transfer of authority. We can never know in advance what limitations to infective invasion are to be set by the patient, but we do know what many surgeons are able to accomplish, for their statistics are available.

My position toward cases that are first seen when an acute attack is evidently subsiding depends on judgment in individual cases and can not be stated as a dictum. Sometimes it is best to operate, in order to shorten the period of convalescence and to avoid the danger of recrudescence of infective invasion. Sometimes it is best to wait for entire subsidence of infection and to choose the interval stage as the time of operation. The advantages of waiting for the interval are not so great as commonly supposed. The reason is that in the interval between attacks we lose the benefit of the local hyperleucocytosis that has been called out by the infection, and the patient has to get up a new local leucocytosis for the surgeon when he finally operates.

My position toward operating in the interval depends entirely on the case. Many patients have had the appendix wholly destroyed in a violent acute attack and never need an operation subsequently unless for separation of troublesome adhesions. Other patients carry chronic infection and mucous inclusions after the subsidence of an acute attack, and these patients call for operation as soon as a convenient time can be arranged. I have had many patients get into trouble because they set the convenient time too far away, and they had to have a hurried operation at a most inconvenient time. It is not difficult, by palpation and by observance of the subjective symptoms, to classify interval cases pretty accurately, so that we know which patients need operation and which do not.

The Incision, and Treatment of the Stump.—Concerning the choice of incision for interval cases of appendicitis, I still hold to the McBurney or gridiron incision. The results are so ideal that I do not dare to change to other types that have been advocated by other operators. The skin incision need not often be more than an inch and a half in length, no matter how extensive the adhesions, and the split muscles fall together so readily that hernia is avoided. A pair of scissors and a needle are about the only instruments that are required in any sort of appendix operation. My position toward treatment of the stump in interval cases has changed several times. I have employed nearly all the methods that have been advocated. Since the publication of Seelig's convincing article on the subject in the *Annals of Surgery,* about three years ago, I have put aside fears and now ligate the stump simply like an artery, dropping it back into the peritoneal cavity after touching it with carbolic acid and neutralizing the carbolic acid with alcohol, which latter should be washed away with a little saline solution to avoid all irritation. This simple treatment of the stump suffices because the stump falls against parietal peritoneum, which walls it in quite as securely as does peritoneum infolded from the cecum. The adhesion to parietal peritoneum is at a point where the cecum is naturally fixed, so no harm results. By dropping fanciful methods of treating the stump we can save from one to five minutes of time, and this will allow the entire operation to be completed without hurry in less than ten minutes in most interval cases.

Cases with Gangrene or Perforation.—My position has changed greatly in regard to treatment of appendicitis cases with gangrene, perforation and products of infection outside the confines of the appendix. Twenty years ago I worked deliberately, made long incisions, and sometimes multiple incisions, for thorough wiping

and flushing of the peritoneum. Gauze drains, gauze packing and other sorts of drainage apparatus were employed. Hydrogen dioxid was used for rapidly throwing out products of infection. I then tried to introduce refinements, in the way of more speedy work. Multiple incisions were discarded and the single incision was made shorter and shorter, until now for most cases of extensive infection I use about the same incision as for interval cases. Wiping and flushing the peritoneum, and the use of gauze drains and gauze packing were gradually dropped, as fast as I could feel that I was on safe ground.

After the publication of Dr. John G. Clark's notable paper in the *American Journal of Obstetrics* relative to complete closure of the abdominal cavity without drainage, in pyosalpinx cases, I tried for about a year, in appendicitis cases with pus and peritonitis, the method of flushing the peritoneal cavity with saline solution and then closing without drainage. Primary union was obtained in many cases. None of the patients died and none had increase of peritonitis. Secondary abscess appeared just often enough to make the method undesirable, and I now use a short wick drain and only one. In patients with thick, fat or strong muscular abdominal walls I sometimes exchange the gutta percha covering of the wick drain for sheet lead, which is benign in the tissues and which maintains a free opening through heavy walls.

In these cases of appendicitis with pus and peritonitis I have not changed from the idea of breaking up adhesions sufficiently to allow of finding multiple pus pockets, as well as for turning out the appendix; but I avoid separation of the entire mass of adhesions, because they immediately reform, and sometimes in undesirable positions. I have little objection to spreading pus on normal peritoneum which gets into the field, or of leaving such peritoneum

covered with pus, as the patient's autoprotective factors care for it promptly. In former years I damaged these patients very much in attempting to do various kinds of "ideal work" with the stump, but for some years now I have particularly avoided efforts at bringing the cecum to the surface in cases in which it would cost the patient too much. The appendix is ligated simply at the bottom of the well, or in the worst type of cases it is not even ligated. A pair of forceps is snapped over the base of the appendix and left *in situ* until the following day.

The appendix in these cases can often be pulled away with the fingers, and in some cases in which it is seen to be black and gangrenous it is not even necessary to do this, as it will melt away and run out in a day or two. It is only in the desperate class of cases, however, that one will need to leave a gangrenous appendix—the class of cases in which it is best to complete the entire operation in three or four minutes. In cases of appendicitis with pus and peritonitis it is best to complete the operation in from five to fifteen minutes as a rule. This not only conserves the patient's natural resistance, but it means a short period of intoxication with the anesthetic. Little attempt is made at protecting the normal peritoneum against pus in the course of the operation, and very often pus is still welling freely from the wound when the absorbent outer dressing is applied and the operation completed. The wound is not sutured closely, and sometimes is allowed to remain without any sutures. In these cases the advantages of the gridiron incision are supreme, as the walls fall together so nicely that hernia is almost confined to fleshy patients. In several hundred appendicitis cases since adopting the gridiron incision there are but four hernias, so far as I know—three in fleshy patients and one in a case of omental grafting for a sloughed cecum.

It was my preconceived notion that fecal fistulas

would occur rather frequently after the sort of treatment that has been adopted for the stump in these cases of appendicitis with pus and peritonitis, but it seldom appears, and when it does it closes spontaneously without attention in a few days. One can keep a fecal fistula going interminably by applying "ideal treatment" of washing it out, inserting drains, and employing antiseptics which are injurious to the delicate granulation tissue. If the fistula is neglected properly, the undisturbed granulation tissue will be quickly replaced by connective tissue and the connective tissue will contract and close the opening.

After-Treatment. — In the after-treatment of these cases of appendicitis with widespread infection I have not dared to try different postural methods which are known to be valuable, as my results have been so satisfactory with the old recumbent position. The Ochsner starvation treatment I have adopted and applied with great satisfaction, except that I prefer to do a three-minute operation promptly in the class of cases in which Ochsner would not operate until later. Murphy's method of slow instillation of saline solution into the rectum I had applied in principle with the Quimby bag for some time before Murphy described the method and presented the profession with a perfected apparatus for its application.

The refinements offered by quick work, short period of anesthesia, as little surgery as possible, avoidance of flushing, wiping, packing and the use of extensive drainage apparatus, meet with such response on the part of patients that no surgeon accustomed to the classical régime could fail to note the advantages of the methods which I have chosen. Patients so dazed by infection that they do not recognize the surgeon at the time of his examination may often be found reading the newspaper in bed the day after the operation.

SCIENTIFIC NEGLECT.

The treatment which is advocated in this paper may almost be classified as a treatment of neglect. Our highly developed art was not satisfactory when applied to cases of appendicitis with pus and peritonitis. There was a lack of harmony between art and appendicitis. For example, in 1904 Dr. L. W. Hotchkiss[1] published a report from one of the hospitals with which he was connected, showing that from 1895 to 1898 the operative mortality rate in cases of appendicitis with peritonitis was 30 per cent. In 1899 Dr. Hotchkiss changed from the accepted methods of the day and turned to methods which conserved the natural resistance of the patient. He did not have a single death in his next seventy-two cases, although they were of the same class as those which had given 30 per cent. death rate under conventional art, and in which 30 per cent. death rate is common over the whole world to-day. In the year when Dr. Hotchkiss changed his methods, Chauvel[2] made a report on the treatment of appendicitis in the French army for three years. There were 171 cases; 83 were treated medically and 88 surgically. Medical treatment had a mortality of 4 per cent. among those treated before the fourth day, 37.8 per cent. among those treated from the fourth to the eleventh day, and over 50 per cent, for those whose affection was not recognized and treated until after the eleventh day. Surgical treatment had a mortality of 42 per cent. among those operated on in the first five days, and 30 per cent. in operations from the fifth to the tenth day. France represents the highest kind of art, and I therefore make this quotation from that country, although nearly all the European countries showed equally disastrous results from attempting to apply the art of the day to the particularly trying class of cases of appendicitis with pus and peritonitis.

1. Med. News, July 2, 1904.
2. Bull. de l'Acad. de Méd., January, 1899.

It has resulted in turning our faces toward a new era in surgery in general.

Twelve years ago, when I reported on a series of 100 consecutive unselected appendicitis operations, with a death rate of 2 per cent., Dr. Keen publicly protested at Denver against the acceptance of such a report, and Dr. Savidge wrote to the *Medical Record,* saying that it must mean selection of cases for report. Since that time so many other surgeons have presented still better statistics that to-day I may perhaps present for purposes of illustrating the theory a report on my last 100 appendicitis operations at the Post-Graduate Hospital, dating from the last patient out of bed on May 1. There were forty-one cases of appendicitis in all stages of acute attack, with no deaths. There were fifty-nine cases of chronic appendicitis of various sorts, with one death. This death was due to ileus caused by faulty readhesion. There are no hernias in the series so far as I know. No patient was refused operation.

CONGESTIVE APPENDICITIS.

Congestive appendicitis occurs with loose kidney and in various conditions causing general obstruction to the lymph and blood circulation of the abdominal viscera. In these cases the swelling develops slowly. There is time for adaptation of the tissues of the tight outer coats to the swelling tissues of the soft inner coats, and the result is very different from that in which rapid swelling leads to compression anemia. There seems to be no further result than a rather tense and tender appendix, which is amply protected, and which does not have a tendency to go over into the infective appendicitis class, so far as my observation counts.

APPENDICITIS BY EXTERNAL INVASION.

A fourth separate class of appendicitis cases may perhaps be made up from those in which the infection approaches from without. Tuberculosis of the peri-

toneum, and various infections from the oviduct, frequently involve the appendix incidentally, attacking the outer coats first. The inner coats swell, and may even undergo destruction, but the process is so slow that we do not look for the mishaps accompanying rapid swelling of the inner coats to the point of compression anemia. The gradual approach of infection from without calls out protective factors which take charge of the field and seem to prevent the occurrence of infective appendicitis, as that term is commonly understood.

THE FOURTH, OR PHYSIOLOGIC, ERA IN SURGERY.

It seems to me that the object lesson of the results of conserving the patient's natural resistance, in cases of appendicitis with peritonitis, has opened the vista of a new epoch in surgery.

In the days of Hippocrates surgery was heroic. That represents the first era. Then came Andreas Vesalius and the anatomists, and we had the second or anatomic era in surgery. Pasteur and Lister introduced the third, or pathologic, era. The pathologic era is the one now prevailing the world over. The dominant idea is to prevent the development of bacteria in wounds and to remove the products of infection by means of our art.

Appendicitis has been so refractory in response to the perfection of the art of the pathologic era that when the rubber glove appeared, representing the last degree of refinement of the art, it seemed to have overset the whole system. The use of the rubber glove necessitates comparatively slow work, the employment of long incisions and work by sight. Geologists tell us that the constant accumulation of snow and ice at the antarctic pole may cause a sudden changing of the axis of rotation of the earth. The rubber glove was the last snowstorm of the pathologic era of surgery, and the sun is now to shine on what is perhaps the most fertile area ever exposed to light.

Our faces are now turned toward Metchnikoff and Wright, with their descriptions of phagocytes and opsonins, and of the natural protective forces of the patient. We are at the dawn of the fourth, or physiologic, era in surgery. We are to conserve the natural resistance of the patient and to turn him over to his phagocytes and opsonins as helpfully as we can. We are to leave the patient in his best condition for manufacturing phagocytes and opsonins, through the shortest possible method of anesthesia and the least degree of surgery which will suffice to turn the tide of battle between bacterium and leucocyte.

That is the new principle—turning the tide of battle only and leaving the patient with his physiology as nearly intact as possible. The first object lesson in support of the new idea was perhaps furnished by the physician who did not believe in operations for appendicitis, and whose patients sometimes recovered, even though they had pus in the peritoneal cavity. These cases required explanation, and we now have the explanation. The patient attended to the bacteria and to the products of infection. Our surgery of the pathologic era had a tendency to damage the patient to such an extent that he could not destroy his own bacteria and products of infection. The object lesson furnished by the patients of the physicians who did not believe in operating for appendicitis, and the object lesson furnished by the results of operations which neglect the details of the art of the pathologic era, are lessons sufficient for a basis of the coming art of the physiologic era in surgery.

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DISCUSSION.

Dr. A. J. Ochsner, Chicago: The members of the American Medical Association have done more to settle the question of appendicitis than any other body of men in the world. At the head of the list of those who have done most in this direction are such men as Morris, Murphy, Mayo, McBurney, Fowler,

Deaver, Richardson and many other members of this Association. At the present time we have come to look on appendicitis in a very uniform manner. There is no longer any dispute regarding the treatment of three of the four forms of appendicitis which Dr. Morris has described. There should be no disagreement whatever about the fourth form if these cases were always treated properly from the very beginning, if at that time the cases were recognized and the treatment described by Dr. Morris were carried out; then there would be practically no mortality in appendicitis and we could absolutely agree on the treatment.

The form of appendicitis in which there is a difference in treatment is limited to a class of cases of severe acute appendicitis with more or less strongly marked peritonitis two days or more after the beginning of the attack. These cases belong to the second variety of appendicitis which Dr. Morris has mentioned in his classification. If all surgeons were as skilful as Morris and the others whose names I have mentioned, there would no longer be any question about this, because if a surgeon with such skill operates on a patient for appendicitis in any stage the chances are largely in favor of recovery.

If the surgeon from his experience with previous cases can say to himself that in any given case under his care the patient with this variety of disease, this perforated or gangrenous appendix, we will say, has a chance for recovery in less than 98 per cent. of cases with operation, then he must adopt the form of non-operative treatment in which an experience with hundreds of such cases has proved that the mortality is less than 2 per cent. Very recently Dr. Murphy showed that in this same variety of cases his mortality is even less than 2 per cent. so that we must now try to approach a degree of recovery which approximates that which he has accomplished in his practice.

About eight years ago I placed before the International Congress at Paris a certain number of conclusions showing that the infected perforated or gangrenous appendix could be eliminated from the general peritoneal cavity until such time as it could be removed with safety to the patient. These conclusions were not made public until I had personally tested and confirmed them for eight years in a large number of cases. Since then eight additional years have elapsed and in the meantime thousands of practitioners have informed me that they have had the same results with the same treatment.

I will reiterate these conclusions in order that every one who wishes may follow them and have similar results.

1. Patients suffering from chronic recurrent appendicitis should be operated on during the interval.

2. Patients suffering from acute appendicitis should be operated on as soon as the diagnosis is made, provided they come under treatment while the infectious material is still confined to the appendix, if a competent surgeon is available.

3. Aside from insuring a low mortality this will prevent all serious complications.

4. In all cases of acute appendicitis, without regard to the treatment contemplated, the administration of food and cathartics by mouth should be absolutely prohibited and large enemata should never be given.

5. In case of nausea or vomiting, or gaseous distention of the abdomen, gastric lavage should be employed.

6. In cases coming under treatment after the infection has extended beyond the tissues of the appendix, especially in the presence of beginning diffuse peritonitis, Conclusions 4 and 5 should always be employed until the patient's condition makes operative interference safe.

7. In case no operation is performed, neither nourishment nor cathartics should be given by mouth until the patient has been free from pain and otherwise normal for at least four days. The same practice should be followed after operation.

8. During the beginning of this treatment not even water should be given by mouth, the thirst being quenched by rinsing the mouth with cold water and by the use of small enemata. Later small sips of very hot water frequently repeated may be given, and still later small sips of cold water. There is danger in giving water too freely, and there is great danger in the use of large enemata.

9. All practitioners of medicine and surgery, as well as the general public, should be impressed with the importance of prohibiting the use of cathartics and food by mouth, as well as the use of large enemata, in cases of patients suffering from acute appendicitis.

10. It should be constantly borne in mind that even the slightest amount of liquid food of any kind given by mouth may give rise to dangerous peristalsis.

11. The most convenient form of rectal feeding consists in the use of one ounce of one of the various concentrated liquid predigested foods in the market, dissolved in three ounces of warm normal salt solution, introduced slowly through a soft catheter inserted into the rectum a distance of two or three inches.

12. This form of treatment can not supplant the operative treatment of acute appendicitis, but it can and should be used to reduce the mortality by changing the class of cases in which the mortality is greatest into another class in which the mortality is very small after operation.

This applies particularly to severe acute perforated or gangrenous appendicitis more than thirty-six or forty-eight hours after the beginning of the acute attack.

To Conclusion 8 is now regularly added the excellent method introduced by Dr. Murphy of administering a continuous enema of normal salt solution with an apparatus which permits the

flow of only a drop at a time, so that it will require at least one hour to introduce 1,000 c.c.

Dr. Alexander Hugh Ferguson, Chicago: In my opinion, it is a dangerous thing to teach that the incision must be a very small one. What is a small incision for one surgeon is not, for physical reasons, a small one for another surgeon. What is a proper-sized incision for the deliverance of the appendix in the hands of one man is dangerous in the hands of another. The incision, therefore, must be of the length necessary to delivery of an infected appendix without rupturing or tearing it.

I can not get over the idea of holding off operation in infected cases. Dealing first with the infected mass is, in my judgment, necessary and must be done with the greatest amount of care. I can not restrain myself from doing something for every case of appendicitis that presents itself to me, irrespective of the number of days it has existed. We can not judge by hours or days of the pathologic condition. In the apparently moribund patients, say between the third and fourth day of the disease or later, I feel like doing something more than washing out the stomach and rectum. I think that at that very stage, when we know that there is pus in that region, demonstrated by the signs and symptoms manifested by the patient, a minimum amount of surgery under local anesthesia should be practiced. Make a very small incision and drain. In other words, create a line of least resistance outward. I believe, however, that many patients have been lost because of the surgeon doing a major operation at that very dangerous time. How many of these patients now die when left to medical treatment alone is a pertinent question.

Dr. D. N. Eisendrath, Chicago: There is one feature of this subject that I wish discussed more fully. It is one which interests particularly the surgeon who is obliged to operate in cases of general peritonitis which the medical man has tried in vain for two or three days to treat by palliative measures. Many of these patients are brought to the surgeon when the abdomen is enormously distended on account of septic paralysis of the intestine, when the pulse is 130 to 160 and the patient is thoroughly septic. The time to bring the patient to the surgeon is in the first twenty-four or forty-eight hours, before there is much toxemia or a great degree of infection. We have learned to leave these advanced cases alone and try to tide the patient over the attack. We elevate the head of the bed, place the patient on starvation treatment and wait until such time as the appendix can be taken out safely in the interval.

During the past nine years Drs. McArthur, Greensfelder and myself have treated thirty-four patients with general peritonitis, and of these we have been able to save 21, or 60 per

cent. This includes not only cases brought in during the first day or two of the attack, but on the fourth or fifth day. My own personal statistics based on work done during the past three years are that I have been able to save eleven out of twelve patients. This has been accomplished by following the dicta Dr. Murphy laid down so clearly: by a rapid technic and leaving good drainage in the wound. Of much importance is the after-treatment. We must learn to leave these patients alone and not meddle too much in the after-treatment. Patients should not be filled up with fluid by mouth. We lost two patients, one my twelfth case, through giving large quantities of fluid by mouth. The result was an acute dilatation of the stomach, and all efforts to give relief failed.

Other points of importance are the use of the continuous salt solution by the drop enema method, first advocated in this country by Dr. Murphy, and the use of the Fowler position. One should be constantly on the watch to detect secondary abscess between the coils of intestine or a subphrenic abscess.

Dr. Carl Beck, New York: If this country had done nothing else than to elucidate this obscure question, it would have done enough for the whole world. Germany, recognizing what America has done, accepts American views. Two years ago a discussion on this subject was held in Berlin before the local medical society. I was invited to take part and was very much pleased to see in use the methods advocated in this country, but the Germans forgot that it was this great country which brought out these ideas. I congratulated the members of the society that they had become so much Americanized, and I am the only American who ever said so to the members of the Berlin Medical Society.

Regarding the care of the appendix, from my own surgical experience, I can say that anything necrotic serves as a place for bacteria to settle.

Dr. William L. Rodman, Philadelphia: One hesitates in entering on a discussion of appendicitis in Chicago, because so much or, I almost said, nearly all the good work in this particular line is being done in Chicago in the last few years. In 1901 I saw a great deal of work done by Dr. Ochsner. It was a revelation to me, and when I heard his epoch-making Chairman's address at St. Paul a little later I returned to Philadelphia determined to put into practice the safe, sound and sane doctrine which I had heard. I was severely criticised in several hospitals for pursuing what I believed from Ochsner's teachings to be a masterly inactivity in cases in which I had been tempted to operate before. It was with some trepidation that I looked for a good result in several instances, knowing that I would be criticised for not operating in such cases the moment I saw them, but I have never yet

felt that I regretted following Ochsner's teachings. I believe that he has done more to straighten out this knotty question of when to operate than any one else who has ever lived.

As for the way to operate and the details of operative procedures and technic, of course, Murphy has swept the floor clean; he has left nothing for anybody else to say. I believe that all of us are getting results in operations for appendicitis today that would not have been possible but for the teaching of these men, because they have looked far ahead of their time and they have been the cause of saving thousands and thousands of lives by discouraging premature, foolhardy operations. As to the technic in operations, I believe in ligation of the stump, provided it is covered with the subperitoneal coat, and at the same time the meso-appendix is brought up and placed as a cap over the appendix so as to prevent any possible infection of the cavity. It is a safer procedure than the mere purse-string method.

Dr. J. H. Stealy, Freeport, Ill.: I fear that two points mentioned will be misunderstood. 1. Leucocytosis does not amount to much in appendicitis. In the first stage it is very important, but many times I have found a leucocytosis of 8,000 or 9,000 and at the operation I found an ounce or two of pus in an abscess cavity. Drainage is valuable in such cases, as in many others, but the secret of drainage, in my opinion, is to know how to handle the drainage after it is once put there. I have operated on a number of patients throughout the country who were left for the practitioners to look after. If there was not much discharge at the end of the second or third day, the practitioners have removed the drainage. As a result, Nature's protecting wall has been torn up, permitting extension of infection, and within twenty-four hours there was a general peritonitis and the patient died.

Dr. C. C. Roger, Chicago: In cases of fibrous appendicitis, when the nerves of the appendix are caught in the fibrous tissue, causing almost constant pain—a condition I have described as neuroma of the appendix—if there is no improvement under medical treatment, the appendix should be removed. What is found on entering the abdominal cavity is simply a hard, white cord, which looks as though its removal were almost useless, but the patient will be cured if it is taken off.

I admit that a leucocyte count does not amount to much. Some of my worst cases of gangrene of the appendix had only 5,000 leucocytes. That is not the rule, however; usually in such cases there is a high leucocyte count. If the patient is overcome with toxins, the leucocytes are low. Make a differential count and if you find over 80 per cent. of polynuclear cells operate; if there are 5,000 leucocytes with 98 per cent. of polymorphonuclears the case is an operative one;

death is imminent and you must operate at once. The leucocyte count, then, is not of much value, but the differential count is of great value. The incision should be short. The appendix can be removed through an incision sufficiently large to introduce the index finger, provided the appendix is not bound down. The incision should be made wherever the appendix is. McBurney's point means nothing, because the appendix may be any place in the abdominal cavity. The point is to make the incision so you can get at the appendix. The time to operate is at sight in the majority of cases. To wait forty-eight hours is nonsense. Suppurative cases should always be drained, but too much drainage is bad and too little is just as bad. The drain is useless if it is removed inside of twenty-four hours. Leave it in place until it becomes slimy and the exudates push it loose (forty-eight to seventy-two hours). The drainage can be removed at the proper time without danger to the patient.

Dr. H. J. Burwash, Chicago: In the postoperative treatment of those cases of diffuse suppurative appendicitis in which there is a liability to obstruction of the bowel I have used with success enemata of oxygen gas. This is introduced early and before marked signs of obstruction present themselves. The gas is allowed to run slowly into the bowel for five or six minutes hourly. It has the immediate effect of neutralizing noxious gases in the intestinal canal, the therapeutic effects of oxygen on the general circulation, and the mechanical effect of preventing adhesions and hence obstructing by keeping the bowels inflated. This does not, I imagine, exclude the treatment advocated by Dr. Murphy.

Dr. H. A. Royster, Raleigh, N. C.: The general practitioner, with whom I come in daily contact, would like to understand two things about the so-called Ochsner treatment. The first is that any treatment intended to tide the patient over a dangerous period does not mean that operation must be abandoned, but that the patient is being prepared for operation. I believe that the Ochsner treatment is the greatest single advance in the treatment of appendicitis, but it is also the most misunderstood method in America to-day. I am sure that nearly every practitioner thinks it is a substitute for operation and not a preparation for it. In other words, if he begins the treatment of a case of appendicitis according to the Ochsner method, he will keep it up, no matter what happens, and, when the patient gets over the attack, rejoices in a cure without operation. If the patient dies, it was God's will.

The second point is whether pus is ever absorbed in the abdominal cavity without killing the patient. I have never understood exactly the teaching on that question. This matter must come up in the minds of the general practitioner, especially when he has a patient with a ruptured appendix,

pus in the peritoneum, and the case goes along without operation under the so-called Ochsner treatment. I think that it is the duty of those who see the general practitioners when they bring these cases to let them understand that Dr. Ochsner, as well as every other good surgeon, believes always in operating early for appendicitis, but never when it is unsafe.

DR. CHARLES E. THOMSON, Scranton, Pa.: I am sure that Dr. Ochsner would blush for his treatment if he knew how it was being carried out in the country districts. What does it mean to the general country practitioner? It means: Do not operate in appendicitis, and it means nothing else. Many of those practitioners have always been opposed to surgery, and now they assert that a great surgeon in Chicago is saving nearly all his cases by not operating on them. I admire Dr. Ochsner, but I think that his theory and principles have been misunderstood, and have thus been the cause of filling many untimely graves. I believe that with the Murphy treatment we can save practically all those neglected cases to which Dr. Ochsner applies his treatment, and that the sooner the non-operative and time-limit theories be eliminated in the treatment of appendicitis the better.

DR. A. J. OCHSNER, Chicago: I am thankful to you for the privilege of a few additional words. I wish to answer, first, the statement made by Dr. Thompson, of Scranton. What he said about misconception of the treatment I have advocated is absolutely true. That is the very reason why this form of treatment was not published six years earlier than it was. I used this treatment for eight years before I made it public. In the meantime men like Mayo and a few others, who had faith in my judgment and in my honesty, were shown these cases, case after case, and many of them adopted the method several years before it was published. Those of you who will come to my hospital will see a patient who was admitted the day before yesterday with a temperature of 104.2 F. and a pulse of 160, a patient who would be dead now if any one had operated on her immediately except some great surgeon with extraordinary, almost superhuman skill, like our friend here. That patient this morning had a pulse of 106 and a temperature of 99 F. I have had many hundreds of these patients in the eight years since the publication of my paper describing this treatment. I have averaged more than one appendicitis operation for every day that has passed since that time, and I have been able to demonstrate thousands of these appendices. I will show this appendix to any one who will come to my clinic next week.

Now, then, should this treatment take the place of operative treatment? In the first paper I wrote and in every succeeding paper on this subject, I have said, "No." This treatment can not replace the surgical treatment of appendicitis, but it will take patients that are sure to die in the hands of

the average surgeon and place them in a condition in which any surgeon with reasonable skill and clean hands can make a safe operation—in which any surgeon of ordinary skill can reduce his mortality from 16 to 2 per cent.

I knew that there would be hundreds of doctors all over the country looking for an excuse for advising against operation for two reasons: first, that they could not afford to transfer the patient to some one else; and, second, that other patients in their practice suffering from acute appendicitis on whom an operation has been done two days or more after the beginning of the attack had died; so that they had, on the one hand, the desire of continuing the treatment themselves, and, on the other hand, fear of a form of treatment which had usually terminated fatally in their experience before. There are thousands of physicians in this country who have read my conclusions again and again and understood and followed them. They have been published many hundred times, so that every physician who knows how to read has had an opportunity to read these conclusions. They will be published again, so that physicians will again have an opportunity to read them. The principle of the thing is simply this (and the same principle holds good now that held good at the first publication): You must place neither food nor cathartics nor water nor anything else within the patient's stomach until he has passed out of this dangerous condition. Then, before you begin to feed that patient, remove his appendix. Of course, there is this danger: that many patients become so extremely well that they will not permit an operation; but there is a remedy for this. You merely place the patient on a liquid diet and tell him that if he goes beyond that before the appendix is removed he will have a recurrence of his attack sooner or later.

As to the Fowler position, you have heard Dr. Morris say that his results have been so satisfactory that he has not added this position to his treatment. Of course not. Any one whose treatment has been so successful would be foolish to change it.

I have added to my treatment, and with great benefit to the patient, the treatment by the drop method of instilling normal salt solution into the rectum which Dr. Murphy has taught us, and I know that my patients have been benefited greatly thereby, not only before but also after operation. And here is one point that I wish to make: Many hundreds of patients have recovered after operation because their surgeons had learned to give neither food nor cathartics after abdominal operations, so that they received the treatment I have advised notwithstanding the operation. I have employed this treatment in many cases that were apparently beyond all hope and still the patients recovered. I know that Dr. Murphy has had exactly the results he has described, and I know that there is an important principle involved. He directs the lymph stream away from the patient and accomplishes the relief of tension.

Pus can be absorbed from the peritoneal cavity. We have demonstrated that thousands of times in operations in which we do not drain. Of course, large quantities of pus are not usually absorbed. If the operation is not performed the pus either makes its way into the intestine, or instead of a quantity of pus being present, there is a mass of omentum walling off the infected area giving the impression of the presence of a large amount of pus.

DR. JOHN B. MURPHY, Chicago: It is approximately two years since this subject came before the American medical profession for discussion. We have agreed on the diagnosis, the time to operate and the limitations of this procedure. Limitations are essential to ultimate success. One must do the least thing, give the least trauma and finish in the least possible time consistent with doing the thing well.

Dr. Ochsner' brought out, probably before any one else, the recognition of the time when it was dangerous to do work in the peritoneal cavity, because the patient had been neglected in the beginning and allowed to get to a position in which he was loaded to the maximum of his vital resistance by intoxication and infection. A painful mortality has brought recognition of the fact that there are cases in which a little additional work means a fatal termination; that trauma in the peritoneum is one of the most dangerous types of trauma. I am convinced that it is not yet safe to let the order go out that the simple ligation of the appendix, without any further protection of the stump, is ample. I feel that we should give an additional protection to that stump other than mere ligation in the acute infected cases. These are the cases in which we are most likely to have leakage when we simply tie the stump and cut it off. In the intermediate cases, in which I have no infiltration, no reaction to inflammation at the time, I treat it by clamping, by tying a ligature in the crease, and then by taking an overstitch so that there is no raw or abraded surface at that point to become adherent, and it will not become adherent. In the active cases I ligate and then put in a drain.

Appendicitis in pregnancy has a colossal mortality, something like 60 per cent. mortality to the mother and about 90 per cent. mortality to the child. I have been endeavoring to estimate the best time to act. In all the cases that come under my observation, in which the patient has had attacks of appendicitis, I insist on an operation before there is another attack and at the earliest time after impregnation. I think that that will give us the best results.

As to the management of peritonitis, we have up to this date had forty-three cases of perforation of the appendix into the free peritoneal cavity with general diffuse, spreading peritonitis. Among these forty-three cases we had forty-one recoveries. One patient died of pneumonia six days after-

ward and another died of intestinal obstruction under my own eyes four days afterward with gangrene of six inches of bowel. In the cases with recovery there was much creamy pus around the abscess. This creamy pus, Nature's means of defence, is loaded with scavenger leucocytes; it is producing a circumscribed inflammation of the peritoneum. That means resistance. In the other varieties of peritonitis and perforation not associated with appendicitis, we have had all together nine cases, making a total of fifty-two cases. Five of these were diffuse with perforation and recovery.

There is pus and pus. Dr. Morris does not mean that the pus of the appendix that has ruptured into the free peritoneal cavity could be cared for without interference, because then we would not need any operations. He means that pus of the staphylococcus, the colon bacillus, or the streptococcus type— and these are the three principal types of pus in the peritoneal cavity— does not, without the element of tension, produce a fatal absorption in any place in the body. He means that the defensive forces of the body are not fully appreciated.

The elements of treatment consist of, 1, closing the opening; 2, relieving the pus tension by putting in a drain; 3, getting out of the peritoneal cavity and leaving in the drain to prevent subsequent tension—no flushing, no washing, no sponging, no trauma. In following out that line of treatment we have not overburdened the patient at the time of the operation with the additional absorption of the products of infection; we have not killed him on the operating table, and these results gained in an experience of five and a half years shows what we can hope for in this disease. Salines are used in all our severer operations of every kind, whether abdominal or not.

Dr. Robert T. Morris, New York: I adopt the Ochsner starvation treatment in principle, but prefer to do a three to five minute operation on a patient when I can; then leave him to his opsonins and phagocytes. The Ochsner treatment is one of the greatest points ever made in the history of appendicitis. The Ochsner treatment as comprehended by the average physician of New York is damnable. We are now arriving at the era of physiologic surgery, of leaving something for the patient's phagocytes and opsonins to do. If we leave this factory of the patient's in good condition, it can go on manufacturing these substances and cure him.

As to simple ligation, what is the difference whether the stump of the appendix lies against the parietal peritoneum or against the visceral peritoneum, the peritoneum of the mesoappendix, which is drawn up over it, or the peritoneum brought up on the stump by the infolding suture? In all these cases the stump lies against the peritoneum, and that is the essential thing if it is promptly walled in by a plastic exudate. We save time by the simple ligation, and time is

the thing we must keep in mind in connection with this new principle, the new era in surgery. Dr. Ferguson is still afraid of pus in the peritoneal cavity. If we use gauze to wall off that area we are doing too much surgery. If we fill the patient with gauze, we are performing taxidermy on him. If we break down the adhesions, what will be the influence if we let a pint of pus into the free peritoneal cavity? That is an albuminous fluid, and it will furnish nourishment to the patient. You may kill him if you try to get it out. Let him get it out. He can do it better than we can. In cases of general peritonitis I believe in the three to five minute operation together with the Ochsner treatment. In the last 100 cases at the Post-Graduate Hospital, 100 consecutive cases of appendicitis, unselected, treated by the method of leaving the patient to his own opsonins and phagocytes, 41 acute cases of appendicitis and 59 interval and other cases, there was only one death. I might have presented other series of cases, but this one will suffice. I have operated on every appendicitis patient with peritonitis who was still breathing when I got to him.

CHRONIC PERITONITIS WITH COMPLETE OBSTRUCTION,

CAUSED BY NUMEROUS CONSTRICTIONS, OF A PREVIOUSLY UNDESCRIBED CHARACTER, THROUGHOUT THE INTESTINE.

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Surgeon of Hope Hospital, Professor of Surgery in Indiana University School of Medicine.
FORT WAYNE, IND.

Patient.—Dr. L. A. H., aged 35, married, was admitted to Hope Hospital May 24, 1907.

History.—Grandmother died of cancer. One aunt died of consumption, and an uncle had "white swelling." Aside from children's diseases, the patient had had an attack of pneumonia in 1886, followed by empyema for which a rib was resected and drainage instituted. Complete recovery followed but the diseased chest still remained considerably contracted. Drank excessively whole of 1903, but is a total abstainer now. In December, 1906 (six months before admission), after a full meal of sausage, he was taken with severe abdominal cramps and vomiting, for relief from which he took ⅜ gr. of morphin hypodermatically. The pain was worse in the lower abdomen, and especially on the right side, and some tenderness, localized over the painful area, followed. This attack caused him to quit work for one day. Six weeks later he had a similar attack, accompanied by vomiting of a light, bright green fluid and a more severe one occurred March 28, 1907. The bowels were constipated. A few days before coming to the hospital he had a formed, putty-colored stool. No elevation of temperature was present during those attacks. Patient stated that abdomen was sore when he was jolted and complained of accumulation of gas in the stomach, which was relieved by belching or the use of the stomach pump. Frequently vomited bright greeen fluid, and complained of a metallic taste in the mouth. Very difficult to get the bowels to move; the stools were not formed.

Examination.—Fairly nourished, good color, dark complexion. Abdomen rather retracted and boggy. An indistinct mass was felt in right pelvic region, both on rectal and abdominal palpation. Examination of the chest was negative. Pulse 62; temperature 97.6 F. Up to two days prior to operation the case was in charge of Dr. G. W. McCaskey, to whom I am indebted for the following clinical facts: The blood picture was normal. Urine normal in character but reduced in amount, only 18 ounces being passed in the twenty-four hours. Bacteriologic examination of vomitus was made by Dr. Rhamy. He reported that he found a bacillus which culturally and microscopically gave characteristics of the *Bacillus typhosus*. Widal reaction positive. Opsonic index to autogenous bacilli, 47. No reaction to two injections of old tuberculin of 5 and 10 mg., respectively. Permeability of the intestinal tube was demonstrated by the charcoal test. No diagnosis could be made other than that of a low grade, wide-spread peritonitis with incomplete obstruction of the bowels. An exploratory operation was thought advisable and accordingly done May 26, 1907, two days after his entrance into the hospital.

Operation.—Ether anesthesia. Midline incision. Practically universal close adhesions were found between contiguous bowel surfaces. A little fluid was found. Very little adhesion between visceral and parietal peritoneum was found. The appendix was freed and removed but presented nothing abnormal. The bowel adhesions were fairly completely broken up. The small intestine seemed abnormally short and nowhere constricted, but on the contrary seemed unusually large in its transverse diameter, and on palpation felt as though it were filled with fish worms. Attempts to empty sections of the bowel by stripping were ineffectual. The surface of the bowel was grayish-white, and the non-adherent surfaces perfectly smooth. An incision was made into the ileum. No escape of feces or gas. Bowel seemed full of mucous membrane arranged in accordion-like folds. A probe could not be made to pass in either direction. The finger could be made to pass in either direction by carefully working the folds aside. It was concluded that the case was hopeless, even temporary relief being out of the question. Accordingly, the intestine was closed by a line of through-and-through catgut sutures and over this a line of continuous linen sutures, and the wound in the abdomen closed by buried catgut and adhesive plaster. The patient left his room for the operating room at 9 a. m. and returned at 11:45 a. m. Just before the operation his pulse was 70, and temperature 97.6 F. Twelve hours after the operation his pulse

was 102 and his temperature 98.2 F. Sixteen hours after the operation a catheter was inserted and the bladder found empty. From the time of the operation until his death, which occurred on the morning of May 29 (three days after the operation), but eight ounces of urine were secreted. It will be remembered that the urine was reduced in quantity when he came into the hospital, owing, no doubt, to the frequent vomiting. There was no vomiting for twenty-four hours after the operation, when it commenced again and continued until his death, which occurred 72 hours after the operation. At first the vomitus was green as before, but later became dark and brown. The temperature gradually rose until it reached 102 F. before death, while the pulse became gradually more frequent and more feeble and death occurred from a gradual failure of the vital powers 72 hours after the operation.

Autopsy.—No record was made of the exact time intervening between the death and autopsy, but it was about two hours. Both the wound in the abdomen and that in the intestine were found to be healing normally. No evidence of recent peritoneal infection. The stomach presented nothing abnormal except some adhesions to the abdominal wall. The whole of the small intestine and all of the large except the rectum was covered by a layer of grayish-white, rather strong, plastic material, about 1/16 of an inch in thickness, which could be stripped off, leaving the underlying peritoneum looking, to the naked eye, normal. This membrane was smooth on the free surfaces of the bowel but ragged where it had been adherent. This adventitious coat did not reduce the transverse diameter of the bowel, but shortened it by actual measurement between 70 and 80 per cent. Closely placed parallel incisions around the bowel would allow it to be drawn out to its normal length, as would stripping off the false membrane (Fig. 1). Mesentery and omentum were normal. The liver, spleen, and peritoneal surface of the bladder were covered, as were the bowels, by this membrane, but not diminished in size. Transverse section of the bowel shows its lumen to be occluded by transverse folds of mucous membrane (Fig. 2).

Specimens were given to Dr. B. W. Rhamy, the pathologist of Hope Hospital, and also to Dr. W. H. Welch of Johns Hopkins. The two reports agree except that Dr. Rhamy found bacilli corresponding to the *B. typhosus,* as did those he found in the vomitus during the life of the patient, while Dr. Welch found no bacilli save those which "were probably the result of post-

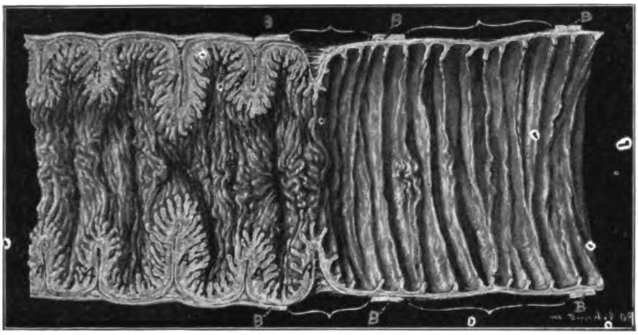

Fig. 1.—Showing inner aspect of bowel as seen on section. To the left at A A A are seen infoldings; to the right the false membrane B B B has been cut, allowing the bowel to be drawn out to normal length. Brackets show bowel pulled out after division of false membrane; length before division ½ inch, after division 2¾ inches. Infolding only partly obliterated under short bracket.

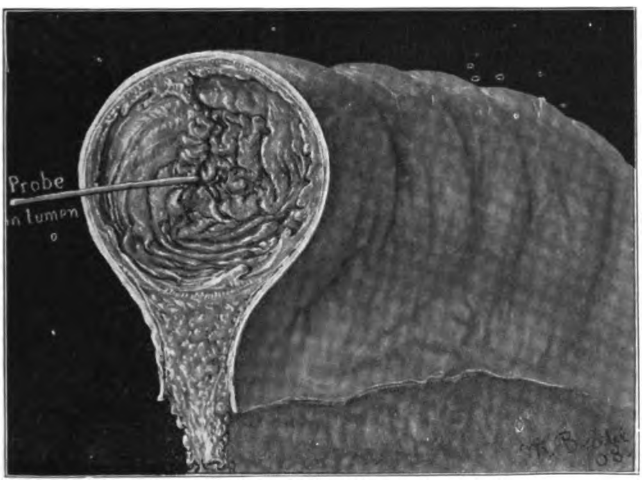

Fig. 2.—Showing occlusion of lumen by infolding of the bowel coats.

mortem contamination." It was endeavored to eliminate postmortem contamination from the specimen examined by Dr. Rhamy, while no such care was taken of the specimen sent to Dr. Welch. This perhaps explains the difference in the opinions expressed as to the cause of the peritonitis. Dr. Rhamy's diagnosis was chronic plastic peritonitis due to typhoid infection. Dr. Welch's report is as follows:

PATHOLOGIC REPORT BY DR. W. H. WELCH.

Gross Appearances.—The specimen, which had been preserved in formalin and alcohol, was a portion of the small intestine, evidently jejunum, which had been severed from the mesenteric attachment except at one end, where a small piece of the mesentery was retained. The specimen measured 21 cm. (8 in.) in length opposite to the mesenteric border, and 15 cm. (6 in.) in length along the mesenteric border. For a distance of 13 cm. (5 in.) from one end the intestine had been cut open along the mesenteric margin, the remaining 8 cm. (3 in.) being unopened. The unopened part of the intestine measured 10 cm. (4 in.) in external circumference, was not collapsed and felt from the outside as if filled with a rather elastic and moderately firm material. The transverse section presented by the cut end of this solid, unopened part of the intestine showed no recognizable lumen, but in its place a complicated mass of folded mucous membrane. Only with difficulty and after much twisting and turning could a metallic probe be passed from the lumen corresponding to the opened part of the intestine through the lumen of the unopened part; after inserting the probe this latter part was cut open opposite to the mesenteric attachment, when it is seen that the obstruction was due entirely to infoldings of the intestinal wall occurring at short intervals and kept in place by an organized false membrane attached to the peritoneal surface. This false membrane covered the entire peritoneal surface of the intestine, but over the opened part of the specimen, as stated in Dr. Porter's letter accompanying the specimen, "closely placed parallel incisions around the bowel, made through the false membrane," had permitted this part of intestine to be stretched to its normal length and had effaced the involutions of the intestinal wall, so that here the lumen was free from obstruction and the mucous surface showed no especial abnormality. It was evident that by a similar procedure the same result could be

obtained in the remaining part of the specimen. There were no contents found in the lumen of the obstructed intestine after opening it as described.

As has already been stated above the entire outer surface of the intestine was covered with a false membrane. This membrane which was from 0.5 to 1 mm. (1/50 to 1/25 in.) in thickness, was grayish in color, of firm consistence, almost cartilaginous in translucence over most of its extent, and smooth over the greater part of its free surface, although careful inspection showed that much of this surface was finely granular or slightly shaggy as would result from a thin coating of fibrinous exudate on an organized fibrous membrane. No remnants of fibrous threads or bands projected from the free surface of the false membrane. This dense and nearly uniform false membrane, consisting apparently of organized fibrous tissue with superficial fibrinous exudate, was attached to the underlying wall of the intestine by fibrillated connective tissue, which was evidently also of new formation. This attachment was in general so loose that there was no difficulty in peeling the dense false membrane off from the intestine, the surface thus exposed appearing smooth in consequence of the delicacy of the severed threads of tissue. The attachment of the false membrane was firmer and more intimate over the intestine situated between the infoldings of the wall, while it was very loosely attached directly over these infoldings. No tubercles could be seen with the naked eye in the outer covering of the intestine or elsewhere.

In this examination the greatest interest attached to the infoldings of the intestinal wall which have filled up and obstructed the lumen of the bowel. As these infoldings had been entirely obliterated in the opened part of the intestine by numerous transverse incisions through the false membrane they could be studied only in the eight centimeters of the intestine which had not been cut open previous to the reception of the specimen. The folds were the result of a sharp bending inward of all the coats of the intestinal wall from a direction parallel to the long axis of the intestine to one perpendicular to this axis, much as if a contraction of a narrow band of the circular muscular coat had occurred and persisted or been held in place. These segmental, transverse constrictions of the intestinal wall followed each other longitudinally at short intervals, as many as eight being present in a length of 8 cm. (3 in.) of intestine. Each of the infoldings extended as a rule transversely nearly around the circumference of the intestine, but some were shorter. There was a certain alternating

arrangement of the folds such that the shallower part of one fold fitted in between the deeper parts of adjacent folds, whereby a spiral-like arrangement of the intestinal ridges on the mucous surface resulted. This arrangement suggested that each infolding corresponded to the course of the larger vessels which run transversely around the bowel, and in many of the folds it was possible to see these vessels in the lax tissue bridging the depressions. The depth of the folds averaged from 1 to 2 cm. (⅜ to ¾ in.), the tendency was for each fold to become shallower in its course and to disappear before it had completely encircled the bowel. The thickness of the folds was about 1 cm. (⅜ in.), the adjacent muscular coats on each side of a fold being nearly in apposition in the deeper part of the depression and separating slightly above, so as to approximate a V-shape. Between successive folds the lumen appeared of normal dimensions, but this lumen was evident only on stretching the intestine longitudinally as the folds were so close together and so deep as to obstruct it completely. The dense false membrane which covered the outer surface of the intestine did not follow the involution of the intestinal coats into the folds, but it extended bridge-like over the depressions, and it was evident that it was these bridges of false membrane which kept the folds in place. By incising these bridges transversely over the folds the latter were readily obliterated on stretching the bowel longitudinally. There was little evidence of the existence of the constrictions on inspection of the outer wall of the unopened intestine, which appeared merely invested in a uniform grayish coat of false membrane; still, careful inspection showed frequent slight external furrows corresponding to the constrictions. The delicate loose connective tissue already noted as present beneath the denser part of the false membrane was, however, present in the depressions, stretching between the adjacent sides of an infolding. It was evident that the existence of the constrictions or folds described must have caused an extraordinary shortening of the intestine. By actual measurement of the part of intestine in which the constrictions were in place (not having been obliterated by transverse cuts through the false membrane) there was found to be a shortening of from 70 to 80 per cent. of the normal length. The inner or mucous surface of the intestine showed no abnormalities other than the ridges resulting from the constrictions. Valvulæ conniventes were high and numerous as in the jejunum. There was no ulceration, necrosis or hemorrhage to be detected with the naked eye. The small tag of mesentery which still remained attached to one end of the intestine was

moderately rich in adipose tissue and contained two or three small lymphatic glands, free from any abnormality.

Microscopic Examination.—The mucous membrane was well preserved and appeared entirely normal. The submucosa also was free from any pathologic change. The circular muscular coat appeared somewhat thicker in the part of the intestinal wall included in the constrictions than in that between these, but this was probably due to the obliquity of the section of the muscle in the former situation. The spaces between the muscular bundles of the circular coat appeared rather wider than normal. The longitudinal muscular coat also appeared somewhat thicker near and in the depressions, but the same explanation probably applies here also. This coat was in places moderately invaded by new connective tissue extending in from the peritoneal surface. The existence of the constrictions was sharply defined on the microscopic sections by the abrupt change of direction of the mucous, submucous and muscular coats, the angle of the bend being almost a right angle, but with its apex rounded off. The distance between the muscular coats on each side was about 2 or 3 mm. at the angle and became less as they approached the point of union of the muscle at the bottom of the constriction. The peritoneum was entirely replaced by organizing exudate and connective tissue. The original subperitoneal tissue could be made out as a layer firmly connected with the longitudinal muscle. Over this was, first, a layer of richly vascularized fibrillated connective tissue, containing many fibroblasts, plasma cells and lymphocytes. This layer was very lax, with wide meshes and numerous blood vessels over and between the layers of the infoldings of the subjacent coats, whereas it was denser and more intimately connected with the adjacent tissues between the successive constrictions. This layer passed gradually into a dense layer of organizing connective tissue of a rather sclerotic or, in places, hyaline appearance, containing fibers and long fibroblasts, disposed mostly parallel to the longitudinal axis of the intestine, leucocytes and developing capillaries. In this layer, old fibrin in process of substitution by connective tissue was enclosed. On the free surface was a fibrinous exudate, in places old, dense and hyaline in character, and in other places fresh, with fibrillated fibrin and many polymorphonuclear leucocytes, with fragmenting nuclei. The layer described under the gross appearances as "false membrane" consisted mainly of the organizing connective tissue and exudate. Corresponding to the constrictions in the intestinal wall the denser part of the organizing exudate stretched across the interval between

the walls of a fold, and did not follow the intestinal wall as it bent abruptly inward. The subjacent delicately fibrillated, very vascular, lax, newly formed connective tissue extended down in long threads which appeared to be stretched and which ran perpendicularly from the under surface of the dense membrane into the depressions, which were thus occupied by this lax tissue with wide meshes. Corresponding to the tops of many of the constrictions the denser texture of the bridges of false membrane extended down for perhaps 3 or 4 mm. (1/8 in.) as a wedge-shaped mass from the under surface of a bridge into the depression, the apex of the wedge lying in the center of a depression. No tubercles were seen in any of the sections. Sections stained for bacteria (for tubercle bacilli, Gram's stain, and methylene blue) showed various bacilli and cocci on the surface of the exudate, but these resembled bacteria found on the surface of the mucous membrane, and were probably the result of postmortem contamination.

Pathologic Diagnosis.—Chronic organizing peritonitis of unrecognized etiology. Intestinal obstruction resulting from numerous transverse infoldings or constrictions of the intestinal wall, these being held in place by bridges of dense, organizing false membrane.

COMMENTS BY DR. WELCH.

After completing the foregoing examination and description I received from Dr. Porter two other parts of the intestine from the same case. These were both of small intestine. One measured 48 cm. in length, and the folds had been largely obliterated by transverse cuts through the false membrane. The other piece was still unopened. The appearances and pathologic changes in these parts were identical with those already described, the same obstruction from infoldings of the intestinal wall existing as in the specimen already described.

The mode of production of intestinal obstruction in this case is most remarkable and quite unfamiliar to me, and, so far as I am aware, previously unrecorded, although I have not searched the literature. The peritonitis was of the organizing, proliferative type associated with fibrinous exudation. It was probably the primary lesion. Anatomic features of interest relating to the peritonitis were the uniformity of the false membrane enveloping the bowel, the absence of fibrous adhesions to any notable extent, the laxity of the layer of connective tissue connecting the dense false membrane with the intestinal wall where the constrictions occurred, and the bridging of the tops of the constrictions by the dense false membrane of

such a nature that when these bridges were cut through around the bowel the constrictions could be completely obliterated and the intestine restored to its normal length and appearance, save for the evidences of peritonitis. Most remarkable were the extent of intestine implicated in this unusual form of intestinal obstruction, all of that submitted for examination being similarly affected, the great shortening of the intestine in length resulting from the myriads of transverse constrictions, and the symmetry and regularity of the segmental constrictions entirely unlike the nicks and puckerings of the intestinal wall resulting from peritoneal adhesions.

It is evident from the description that the dense false membrane was responsible for keeping the constrictions in place. A further question is whether it was also responsible for their original production. If it be assumed that in process of organization of a progressive fibrinous exudate a false membrane, composed partly of connective tissue, was formed, that this surrounded the bowel uniformly, and was firmly adherent around the bowel at intervals, then it would seem that contraction of this false membrane in a longitudinal direction in consequence of the growth of cicatricial tissue would draw the intestinal wall into transverse folds at the situations where the contracting membrane is loosely attached. Mr. Brödel, who has kindly contributed the drawings (Figs. 1 and 2) accompanying this report, and who is not only an admirable artist but also a skilled anatomist, has called my attention to the possibility of explaining such a disposition of the false membrane and the situation and regularity of the constrictions by taking into account the arrangement of the intestinal vesssels. On an injected and moderately distended small intestine, slight transverse furrows can be seen, each corresponding to the course of an artery which passes from the mesenteric border over the side of the intestine, these arteries alternating as they pass now to one, now to the other, side of the intestine.

As already noted the constrictions seemed to correspond to the situation of these arteries. The suggestion is advanced, therefore, that the situations where the false membrane was loosely attached and where, therefore, the constrictions occurred, correspond to these arterial furrows, and that the constrictions themselves were due to contraction in a longitudinal direction of the organizing false membrane which was firmly adherent to the intestinal wall between the furrows. The distinguishing feature of the process in accordance with this view and as seems supported by the histologic characters described, is the peculiar mode of organization of a peritoneal exudate

whereby the resulting membrane is firmly adherent in places to the intestinal wall and only loosely adherent in intervening places. As already noted the fibers and fibroblasts in the organizing membrane had a prevailing direction parallel to the long axis of the intestine, and this arrangement may account for preponderance of contraction in this direction.

The mechanical explanation which is offered is advanced as an hypothesis without strong proof. Other hypotheses have suggested themselves which take into account the participation of muscular contraction during life in producing the constrictions. In the stage of chronic peritonitis represented in this case, at which the acute exudate is far removed by intervening newly formed connective tissue from the muscular coats there is no reason to assume paralysis of these coats during life.

While it is apparent that the anatomic condition in this case was in no sense intussusception, the possibility may be entertained that muscular contractions causing the bowel contractions may have been such as would initiate intussusception, but that the dense false membrane covering the intestine was an obstacle to the production of actual intussusception.

Nothing was found to indicate the cause of the peritonitis by examination of the specimen sent me.

Dr. Welch's report was written Aug. 14, 1907. Up to the present time, April 8, 1908, he has been unable to find among several of his pathologist friends of wide experience any one who had ever seen or heard of a similar case. My search of the literature has been extensive but not exhaustive and I have found no similar case. Further investigation of the literature is now being made for me and the result will be reported later.

The strange thing to me in this case is not that the bowel should be infolded, shortened and hence obstructed, as it is, by a false membrane of such character and distribution as we have here, but that we have a membrane of this character so generally and evenly disposed. Given a membrane of the quality of the one found, disposed as it was, and it seems to me that the infolding, shortening and obstruction such as found in the case reported is the natural and almost necessary result. The natural tendency to contract, which is inherent in tissue such as that composing this membrane,

would, under the circumstances, be enhanced by the contraction of the longitudinal fibers of the intestine. The tendency to circular constriction would be combated by the bowel contents and the infolding of the bowel coats.

In other words, in a case such as this the contracting force of the false membrane and the longitudinal fibers of the bowel worked together without resistance, whereas the tendency to circular contraction or constriction was opposed by the bowel contents and the infolding. The outer surface of this false membrane is older and, therefore, firmer than the inner surface. This permitted the circular fibers to pull away from the false membrane, thus forming the folds, which finally filled the bowel and prevented circular constriction by the false membrane. In other words, the conditions found seem to me to illustrate the result of comparatively equal forces acting in opposite directions, the one meeting with resistance and the other with none.

DISCUSSION.

Dr. G. W. McCaskey, Fort Wayne, Ind.: It was my privilege to observe this patient for two or three weeks prior to turning him over to Dr. Porter. The case presented features of extraordinary interest. The complaint at the outset, when the patient first consulted me, was general abdominal pain and persistent green vomitus. I thought at first that I had to deal with a pyocyaneus infection. I made a culture and found an organism which corresponded morphologically to the *Bacillus pyocyaneus*. I turned it over to a bacteriologist, who said that it was the Eberth bacillus. Since then I have corresponded with the patient's family, but could get no history of anything even simulating typhoid fever.

I think that tuberculosis can be fairly excluded from the case. I had two injections of tuberculin given, first 5 mg. and then (time not permitting larger injections) 10 mg., but could not get any reaction whatever. I am sorry that I did not have the tuberculo-opsonic index taken. I did, however, have a pure culture made of the bacillus found, and the opsonic index for this organism was about 0.43. I then had an autovaccine made from this, gave several injections, bringing the opsonic index up to about 1, but, of course, the case went on just the same. We may have an organism which overcomes the blood

resistance and to which the opsonic index will be low, yet that organism may possibly not have anything to do with the pathologic conditions with which we have to deal, although I think it quite possible in this case that this organism was the cause of the lesion. Whatever the infection was, it was progressive at the time of the operation. Dr. Welch says that the plastic exudate did not cover the mesenteric peritoneum, but was limited to that portion covering the intestine. This circumstance, I think, points to the conclusion that the exudate was due to an intraintestinal process, and in all probability was bacterial in character.

From the exclusion of tuberculosis and the finding of a bacillus resembling the Eberth bacillus I think that we may possibly have had to deal with an atypical chronic typhoid infection. It might be alleged in this case that we had a latent tuberculosis to deal with, and consequently no reaction was obtained to the tuberculin injections. The process was not latent, however. Dr. Welch says that there was continual new formation of plastic exudate, so that it is fair to say that the infectious agent was active at the time, and, inasmuch as the patient did not respond to 10 mg. of tuberculin, I think we can with considerable probability exclude tuberculosis as an etiologic factor in this case. At first it looked like a case of intestinal obstruction, but I used the charcoal test, and the charcoal passed through, which I think extraordinary, since Dr. Welch could scarcely introduce a probe. The case, so far as I know, is absolutely unique. A study of the gastric contents threw no light on the case. There were about 30 or 40 degrees of free hydrochloric acid. The leucocyte count was within the normal range. Although we concluded that there was plastic peritonitis, neither of us had any idea of the real pathologic findings at the autopsy.

THE PRESERVATION OF ANATOMIC DISSECTIONS WITH PERMANENT COLOR OF MUSCLES, VESSELS, NERVES AND ORGANS, BY A NEW METHOD.

A PRELIMINARY NOTE.

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NEW ORLEANS.

Since all times, anatomists have tried to preserve dissections with permanent color of muscles, vessels, nerves and organs, but, as far as I know, they have failed in securing permanency of color.

The specimens I have seen in the northern and European museums have all the tissues bleached.

It is not so very important to preserve permanently the actual color of muscles, which varies from one subject to another, but it is essential that there should exist permanently a marked contrast between the fleshy parts of muscles and the tendons, fasciæ, bones and other white tissues, which must remain as white as possible. A dark brown color of the fleshy parts of muscles is satisfactory. The more red the brown is, the better and the prettier.

The specimens should retain their color at least five or six years or else the result would not compensate for the labor and expense. We have specimens with color that are over eight years old. Since the color has kept that long I believe it will keep indefinitely, provided the solutions are changed as soon as they become cloudy.

In my work I have used no newly-discovered chemical. I employ the old arsenic and alcohol, to which

I have added carbolic acid, formalin and glycerin. These are the compounds used in colleges all over the world, but it is the combinations and proportions that make all the difference between success and failure.

I started by determining the properties or action of each combination in all the proportions I could think of and letting them go on to do their best or their worst without interfering with them beyond changing the solutions when they became cloudy or discolored. I also experimented to determine the action on color of the lapse of time when the specimens were placed in closed empty jars, without any solution in the jar. Altogether I have seventy jars, representing as many experiments. At the end of a year each specimen was examined critically for color, and it was found that six had turned a good color. All the specimens that lost their color did so within two or three months. A new set of experiments was then undertaken, to determine which of the six methods was the best, cheapest, quickest and simplest. I finally came to the conclusion that the following method was, so far, the best in all respects:

1. Lean, male adult subjects should be used. Fat, however small in quantity, makes bad preparations.

2. The subject should be embalmed with the following formula: A. Water, 1¼ gallons; arsenious acid (saturated solution), 1¼ gallons; nitrate of potash, 1 pound; formalin (formaldehyd, 40 per cent.), 6 ounces. B. Alcohol, 16 ounces; carbolic acid, 6 ounces; glycerin, 16 ounces; creosote (beechwood), 2 ounces. The two solutions, B and A, are to be mixed. I tried seven different formulas and used forty subjects before finding this formula, which seldom fails to give a satisfactory color, dark brown, for the muscles. The color may show only a few days after the embalming, but it is seldom that it disappoints. This sometimes happens, though due, I think, to the fact that the chemical composition of the tissues is not the same in all subjects. If, before dissecting, one waits three to six weeks after the embalming, the color is better; but after more than five or six weeks the white tissues often become of a dirty, whitish yellow.

3. The arteries and the veins may now be injected, if desired. This is done with hot tallow, colored with vermilion for the arteries and ultramarine blue for the veins.

4. Now the subject is partitioned off, that is, divided into a number of pieces according to the preparations that it is desired to make.

5. Each piece is placed in a glass jar filled with a solution of 1 ounce of formalin to the gallon of water (F. 1). This is changed as often as it is discolored by the blood.

6. When the specimen has been purged of its blood, it is suspended in an empty glass jar with a lid on, and is left to drain off its superfluous water. This requires ten days, more or less.

7. The dissection is then made. It should be done with the parts in the position in which they will stand when exhibited or used in demonstrating. There should be a separate specimen for each layer. In order not to destroy their situation, direction, course and relations, the structures in one exposed layer should not be raised from their beds.

8. When the dissection is completed, if the muscles present a satisfactory color (dark brown), the specimen should be immersed in a strong formalin solution, after the idea of Kaiserling, using 10 ounces to the gallon (F. 10), and leaving the specimen in for three days. When after the dissection the muscles present an unsatisfactory color, especially if they present a raw appearance in part or in totality, the specimen should be immersed in a weak carbolic solution, 1 ounce to the gallon (C. 1). The solution should be changed as soon as it becomes cloudy and the specimen should remain in the C. 1 until the solution stays clear. This distinction in the use of a strong formalin or of weak carbolic is important, because if the muscles are not truly dark brown, especially if they are of a raw color, the formalin turns them into a brown gray or bronze color that no later treatment will change. C. 1 used in place of F. 10 when the muscles present a satisfactory color, often gives good results. Sometimes the results are better than with F. 10. It is all, I think, according to the chemical composition of the tissues of the various subjects. Usually the muscles pale somewhat or change color, when placed in any one of these solutions, but later on in the process the color returns.

9. When the dissection has ceased to purge it is placed in an empty glass jar with a lid on and is allowed to cure. This curing stage is of great importance, second only to the embalming formula, as it develops or brings out again the color, without darkening the tendons or other white tissues.

It also smoothes the surfaces, which may be shreddy and ragged; it sharpens the edges of the muscles, thus giving better definition. It fixes the color so as to keep it from being perceptibly affected when the specimen is put up permanently in a solution of alcohol. Even a weak solution of formalin will not affect it much. This curing stage should last until a satisfactory color is attained, but not less than one month. It sometimes requires two or three months, or more, for the muscles to acquire a satisfactory color (dark brown).

10. The arteries must be painted with a vermilion red and the veins with a cobalt blue. The best material is the moist colors (gouache colors), originally used by Dr. Gwilym Davis. They should be allowed to dry thoroughly before the dissection is placed in the following solution.

11. Finally, the specimen is placed in a glass jar filled with a solution of 20 ounces of alcohol to every gallon of water (A. 20).

12. The solutions should be changed as often as they become slightly cloudy or discolored. This is essential to the permanent beauty. Otherwise the impurities in the cloudy or discolored solutions will settle on the white tissues, stain them and destroy their whiteness and brilliancy.

13. Some specimens are refractory to redeveloping color. If after ten or twelve weeks of curing the color has not become satisfactory, place them in A. 20 notwithstanding. If after six or eight weeks in A. 20 there is still no satisfactory color, put them up again to cure for eight or ten weeks or more. The tendons sometimes become horny, but they usually regain their whiteness after they are re-immersed in A. 20. If even then no satisfactory color has redeveloped, put them up in C. 1 until they do. There is here some risk of the tendons and other white tissues acquiring a red gold tinge. As soon as there is any positive sign to that effect, the specimen should be drained for a few days and then immersed permanently in A. 20. Very often the A. 20 will pale the red gold color of the tendons. Thus may be saved some valuable specimens which have cost much time and labor. If this fails the specimen should be made over again with the hope of securing a more favorable result.

That uniformity of color and results does not invariably follow uniformity of procedures is due, I believe, to the fact that the chemical composition of the tissues varies with the subjects. It must be well understood that these two processes are recommended

only in cases of refractory specimens which presented a satisfactory color after the dissection was completed. Those specimens which presented an unsatisfactory color after being dissected will seldom respond. I estimate so far, that 85 or 90 per cent. of the specimens turn out satisfactorily. The remainder are merely good, but not good enough to be placed in a museum. Some specimens have to be done over two or three times before one is obtained that is good and pretty enough to be put in a museum.

The colors in specimens that no chemical or other treatment will improve are gray (dark or light), bronze, brick (uric acid color), coffee and milk (medium or light), and pale pink.

14. The other solutions employed for temporary immersion, instead of C. 1 or F. 10, are alcohol, 20 ounces to the gallon (A. 20); alcohol and carbolic acid (A. 20, C. 1); alcohol and glycerin (A. 20, G. 10); and glycerin and carbolic acid (G. 10, C. 1). They give fairly good results often enough, but not as often as C. 1 or F. 10, nor as good.

15. When specimens become too dark they should be placed in a solution of 20 ounces of alcohol and 1 ounce of formalin (A. 20, F. 1) to each gallon of water. As soon as they have attained a satisfactory color, remove them and put them back in A. 20.

The great practical value of this new method is to give us the means of building study museums composed only of real dissections placed in large glass jars in spacious rooms, flooded with light, on tables so that students can come right to them and study them. Each structure in each specimen is marked by a number and on an appended card the name of the structure is opposite the number. Thus the students can prepare for the dissecting room; they see the innumerable things they never see in a dissecting room; they are able to review and fix in their minds what they have already dissected themselves; the practitioners can in a few moments relearn much anatomy. Such is the study museum that I am now building for the Medical de-

partment of Tulane University in New Orleans. Its full usefulness, however, will be brought out only by allotting on the lecture card one hour three times a week for students to study the preparations and by letting them understand that a quiz on these preparations will bé a part of their final examination in anatomy.

The same method gives similar results for pathologic specimens, provided the subjects are embalmed with the foregoing solution before the postmortem examination is made.

However, this solution often affects the color of the stomach and intestines. A weaker one will not do so and will assist materially in preserving the color in making pathologic specimens. It will also delay the decomposition of the body for several days in this New Orleans climate in August, when subjects decompose in a few hours. On making the postmortem of such embalmed subjects the embalming passes unnoticed. The solution is composed as follows: A. Arsenic (saturated solution), one and a half gallons; nitrate of potash, one-half pound; formalin, two ounces. B. Alcohol, sixteen ounces; carbolic acid, four ounces; glycerin, sixteen ounces; creosote, two ounces. The two solutions are to be mixed.

The following is a formula which is best suited for embalming subjects to be used in the dissecting room; A. Water, one and a half gallons; arsenious acid (saturated solution), one gallon; formalin, eight ounces. B. Alcohol, sixteen ounces; carbolic acid, eight ounces; creosote, two ounces; glycerin, sixteen ounces. B. and A. are to be mixed. The arteries are distended with cornstarch colored with crimson anilin, the diffusibility of which is regulated by a solution of tartar emetic.

I have worked out the formula used at Tulane for subjects for operative surgery: A. Arsenious acid (saturated solution), two and a half gallons; nitrate of potash, two pounds; formalin, four ounces. B. Alcohol,

sixteen ounces; carbolic acid, eight ounces; creosote, two ounces, glycerin solution. B. is to be mixed with A.

The foregoing is only a preliminary note. I shall proceed with the work for some time. Then I propose to publish another note in which I shall mention the improvements, if any, and in which I shall give numerous technical details useful to those who may wish to engage in such work and build also study museums for their universities.

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DISCUSSION.

Dr. Peter Potter, Butte, Mont.: Over half the value of some of the greatest anatomic work which has ever been done is lost because we have only a written record of the work. For instance, Pirogoff, the Russian surgeon and anatomist, was able to get an unlimited amount of material, and climatic conditions were such that he could do much work which could not be done in a warmer climate. The result of his work is contained in five volumes of text and figures. His method was to freeze the body and cut into sections, but the moment his studies were completed and drawings made, the material was destroyed. If we had that material to-day, preserved as Dr. Souchon would preserve it, together with his text and figures, it would be of incalculable value.

Braune of Leipsic reproduced his drawings in a manner that has never been equaled; still his work is incomplete because his material was destroyed after his book was published. The proper preservation of material would enable us to correct mistakes and complete unfinished work of other observers. Even Braune is said to have made mistakes, but this can not be proved or disproved, because his material can not be replaced, and we have nothing but his record and charts. If the material had been preserved an anatomist could go over the work and correct an error, if there was one, or confirm Braune's observations.

Something should be done in this country along the line suggested by Professor His of Leipsic toward establishing an anatomic and histologic institute which would be a central depository for material, microscopic and macroscopic, anatomic or surgical, which has been the basis for original work of merit. The material could be deposited there, and afterward studied and examined by anatomists and surgeons, or any one capable of doing the work, not only to correct errors, but to complete work which even our foremost men are often unable to finish in a lifetime. There is one institution in this coun-

try which, I suppose, is looking toward that end, although I have no authoritative information on the subject. It is my impression that we ought to encourage the Wistar Institute of Philadelphia to take charge of such work and material preserved as is done by Dr. Souchon. If the Wistar Institute is not in a position to take up this work, this Section should be.

Whatever solution is used, it must be a solution that is permanent. Another method of preservation is the use of formalin. A 50 or 100 per cent. solution of formaldehyd is the best for preserving specimens, but it does not retain the original color. If we can get a solution that will preserve the specimen as well as formalin does, and retain the color of the tissues as Dr. Souchon's method does, we shall have an ideal preserving method.

A STUDY OF SIX HUNDRED AND THIRTY-FIVE CASES OF INFANTILE PARALYSIS.

WITH ESPECIAL REFERENCE TO TREATMENT.*

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The following paper deals with an analysis of 635 consecutive unselected cases of infantile paralysis seen at the Orthopedic Out-Patient Department of the Childrens' Hospital, Boston, between Jan. 1, 1897, and Jan. 1, 1908. We are indebted to the Orthopedic Department of the Hospital for permission to report the cases, and to the neurologist for the privilege of consulting the records of that department in cases common to both clinics. The investigation was begun eighteen months ago, and so far as possible the cases have been examined personally by one of us.

FUNDAMENTAL ANATOMIC CONSIDERATIONS.

We are dealing with a lesion of the motor cells of the anterior horns of the spinal cord, and, as it is obvious from the pathology that the harmful agent reaches these cells through the blood current, the relation of the arterial supply to the motor cells becomes of importance.

Spinal Motor Cells.—The spinal motor cells lie in spindle-shaped bundles in the anterior horns of the spinal cord, being chiefly located in the cervical and lumbar enlargements. The greatest extent of these groups is in the length of the spine, one group fre-

*From the Children's Hospital, Boston.

quently reaching through two or three spinal segments, while it overlaps other groups lying above and below it. Whether such group represents an anatomic set of muscles or whether the cells represent a functional grouping, as held by Lapinsky, is not settled, but in any event the relations of the cells to others in the same group and to those of other groups is most complex. One center will send impulses to two or more muscles, and, on the other hand, one muscle will receive motor impulses from more than one group. This matter of the complicated origin of motor impulses becomes of great importance in considering treatment.

Blood Supply of Spinal Cord.—The blood supply of the spinal cord is derived chiefly from one anterior and two posterior spinal arteries. This anterior artery runs the length of the cord in the anterior fissure and is the chief supply of the anterior cornua. It is with the distribution of the blood supplied by the anterior spinal artery that we are chiefly concerned. From this anterior spinal artery there arise two lateral horizontal branches, one to each side, which enter the cord at different levels, about 200 in number. These are the central or sulco-commisural spinal arteries. Entering the anterior cornua, they terminate in a network after subdividing into various branches. Each of these central arteries has ascending and descending branches, covering an area in the length of the cord of from 1.5 to 2 cm. These branches are terminal arteries and do not anastomose with each other. Although they supply chiefly the anterior horns, there are branches to the bordering white matter and one posterior branch.

The terminal twigs of the central arteries do not individually supply each an especial group of motor cells in the anterior horns, but are distributed apparently without reference to the cell groups so that each cell group gets its blood supply from several branches of one central artery or from those of more than one cen-

tral artery. The irregular distribution of destruction of foci in infantile paralysis is thus explained, being dependent on the fact that the lesion follows the blood course and is determined by the distribution of the arteries affected.

The main fact is that, on the whole, the groups of motor cells run in the length of the cord and have their associations in this direction, and that the blood supply is mainly horizontal. Hence, unless the lesion is very extensive, some cells in a group are likely to escape destruction. *The utilization of such remaining cells in partly destroyed groups becomes, therefore, one of the most important objects of treatment.*

ETIOLOGY.[1]

Bacteriology.—Most examinations of the fluid obtained by lumbar puncture by observers all over the world have been negative. In about thirty cases organisms have been reported as present in the last ten years, but these organisms have differed, the most constant finding being the report of fifteen cases by Geiersvold and Harbitz and Scheele,[2] where the same diplococcus was found.

Experimental Production.—Paralysis of a sudden type frequently occurs in laboratory animals, especially in young ones. Lesion of the cells in the anterior horns of the cord has been found in experimental paralysis caused by the injection of staphylococci, streptococci, colon bacilli, pyocyaneus, and other organisms in rabbits. A selective action of certain poisons for the anterior spinal cells is thus shown, and the same is true of some of the metallic poisons, such as lead and arsenic.

Epidemic Character.[3]—That the disease occurs in epidemic form is well recognized, distinct epidemics having been reported from France, Italy, Germany,

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1. Lovett, R. W.: General Review of Etiology. Boston Med. and Surg. Jour., July 30, 1908; Trans. Massachusetts Med. Soc., 1908.
2. The Journal A. M. A., Jan. 25, 1908.
3. Holt and Bartlett: Am. Jour. Med. Sc., May, 1908.

Austria, Norway, Sweden, Australia and in the United States from California, Alabama, Massachusetts, Maine, New York and Vermont. New York City in the summer of 1907 experienced the most severe epidemic ever yet reported anywhere.

Contagion.—The comparatively frequent occurrence of more than one case in a family suggests the possibly contagious nature of the disease or infection from a common source.

Traumatism.—A history of trauma was given in 47 of our series where a history was obtained, and occurring in so large a proportion of the cases it seemed worthy of notice. In 32 cases there was given a history of accident followed almost immediately by paralysis, as shown in Table 1.

TABLE 1.

	No. of Cases.
A.—Slight accidents:	
Slight fall	20
Fall from cradle	3
Fall from chair	1
Fall from swing	1
Fall from carriage	3
Fall from automobile	1
Fall while walking, skating or playing	5
Dropped by nurse	1
Falling under other children	1
B.—More serious accidents:	
Fall from a third-story window	1
Fall from first story window	1
Stone fell on the head	1
Gate fell on the foot	1
Fracture of tibia	1
Total	41

In all of these cases the paralysis followed immediately or so shortly after the accident as to suggest to the parent's mind the relation of cause and effect.

In a second series of six cases (Table 2) the paralysis did not follow the accident immediately, but came on at an interval of some days.

TABLE 2.

Fall from chair	Paralysis a few days later
Fall from carriage	Paralysis a few days later
Fall from bed	Paralysis 7 days later
Fall	Paralysis 3 weeks later
"Injury"	Paralysis 1 week later
Sprain of ankle	Paralysis later

Of these 47 cases, 16 were rejected on the ground that the history was not sufficiently definite as to the traumatism, leaving 31 cases where a clearly described accident or fall preceded the paralysis immediately or at an interval of a few days.

We do not consider that our cases, suggestive as they are, establish the traumatic origin of anterior poliomyelitis, but that so large a number give a clear history of trauma preceding the paralysis we consider worthy of serious consideration in formulating the etiology. Unless one is disposed to dismiss this evidence as necessarily untrustworthy, which seems hardly justifiable, one of two suppositions seems likely: (1) Either trauma may be regarded as predisposing to infection of the spinal cord, or (2) trauma causes a disease so closely resembling anterior poliomyelitis as to be indistinguishable from it. In 234 cases of infantile paralysis reported to the State Board of Health of Massachusetts as occurring in the state in 1907, there were 35 authentic traumatic histories given by the family physician in attendance at the time after rejecting all questionable ones.*

The association of trauma and anterior poliomyelitis has not been wholly overlooked in literature. A case is reported by Borckhardt[4] where a child, 1 year old, was scalded in the face by boiling water. Vomiting and fever followed in a few days with paralysis, and four days later death ensued, the autopsy showing the characteristic changes of anterior poliomyelitis. The other cases reported are mostly or wholly those of adults, the class of accidents described being practically identical with those in this series. The cases are as follows: von Leyden,[5] 2 cases; Stark,[6] Perrin,[7] Meyer,[8] Flatley,[9] and Bullen,[10] one case each.

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* Boston Med. and Surg. Jour., July 30, 1908.
4. Arch. de méd. des enf., October. 1902, p. 608.
5. Arch. f. Psychiat., 1876, vi., 271.
6. Neurol. Centralbl., 1904, xxiii, 14.
7. Arch. de méd. des enf., October, 1902, p. 608.
8. München. med. Wchnschr., 1901, No. 5.
9. Am. Med., 1904, viii, 956.
10. Jour. Ment. Sc., 1892, xxxviii, 71.

Unusual Onset.—In the analysis of the onset of these cases there separated itself a group of cases where the onset was atypical or associated with other diseases. In six cases the paralysis appeared slowly and gradually without febrile attack. In eight cases the onset of the usual character followed exposure to cold. In one case the disease manifested itself on the day after the child had been jumping rope to excess. In thirty-five cases it was said to have followed or to have been associated with the diseases enumerated in Table 3.

TABLE 3.

	No. of Cases.
Bronchitis	3
Bilious attack	1
Teething	2
Nephritis	1
Typhoid fever	5
Scarlet fever	3
Measles	3
Pneumonia	2
Intestinal diarrhea	8
Rheumatism	5
Diphtheria	2

The diagnosis of these cases is, of course, doubtful, as the original onset may have been mistaken for any of these diseases, and there is no means of knowing whether this diagnosis was made by the parents or by a competent physician.

Two further subdivisions of the general group deserve special mention. Two patients became paralyzed during an attack of boils or abscesses, which is of much interest in connection with what has been said in the bacteriology about experimental septic infection, and one patient was paralyzed in the hospital ward during recovery from an operation for appendicitis. Twenty-three cases were said to have followed cerebrospinal meningitis. It is fair to assume that the majority of these cases of so-called meningitis were merely the routine onset of the disease of rather severe character, but in six cases the character of the meningitis was established by hospital observation and the subject has already been discussed by Dr. W. N. Bullard, neurologist to the hospital.

Summary of Etiologic Evidence.—The disease is generally believed to be of infectious origin, but direct bacteriologic proof is as yet absent. The character of the onset, the epidemic distribution, the apparent contagiousness, and the experimental production of paralysis in animals all point in this direction. The fact that the disease selects by preference children in the first dentition and prevails in the summer and early fall offers a close analogy to the gastrointestinal disease and suggests a possible source of infection in the intestinal tract, possibly from some bacillus contained in milk. It may be that such a bacillus liberates a toxin which is the harmful agent and disappears.

With the evidence offered by our cases we can not be sure that the disease represents infection by one specific organism nor tht it is always of infectious origin for it must be remembered that the clinical picture may represent only the reaction of the spinal cord to one of several causes, such as pyogenic organisms, the results of exposure to cold, traumatism, etc. We have not yet sufficient evidence to say whether we are dealing with a specific infectious disease or with a disease of more than one origin.

Sex.—Of the 635 patients, 334 were boys and 301 were girls.

Age.—Table 4 shows the age at onset.

TABLE 4.

Age.	No. of Cases.
Early	8
Under six months	15
6-12 months	55
1 year (second year of life)	150
2 years	128
3 years	65
4 years	40
5 years	36
6 years	18
7 years	13
8 years	8
9 years	7
10 years	6
11 years	4
12 years	1
13 years	1
Total	555
Not noted	80

Season of Onset.—Most of the cases where the date of onset was noted ocurred during the spring and autumn months, as shown in Table 5.

TABLE 5.

January	8	July	36	Spring	8
February	4	August	43	Summer	17
March	5	September	47	Autumn	13
April	5	October	39	Winter	7
May	6	November	29		
June	13	December	4		

Relation of Severity of Onset to Paralysis.—The character of the onset was tabulated with regard to the degree of paralysis following, to see what, if any, relation existed.

The onset was classed as severe when it lasted over a week, or was accompanied by unconsciousness, delirium convulsions. It was classed as moderate when it was from a day or two to a week in duration, when the symptoms were not alarming and when the fever was moderate. It was classed as slight when the child was affected by a slight febrile attack for one or two days, when the temperature was but little elevated and the illness apparently trifling.

The paralysis was classed as severe when it was complete in one limb, when it involved more than one limb to any serious degree, or when walking on the paralyzed leg was impossible. It was classed as moderate when important groups of muscles were affected enough to make the child seriously lame, when marked deformity was present, or when it was the cause of moderate disability. It was classed as slight when only one muscle or an unimportant group was affected, when the limb was merely weak, or when serious lameness and disability were absent. Arranged in this way, the results were as shown in Table 6.

TABLE 6.

Character of Onset.	No. of Cases.	Paralysis. Severe.	Paralysis. Moderate.	Paralysis. Slight.
Severe	98	51	28	19
Moderate	84	25	44	15
Slight	62	11	28	23
No attack at onset	31	2	10	19

From this it appears that a severe onset, as defined above, is more likely to be followed by severe paralysis than by any other type, and that slight paralysis is unlikely (19 in 88). A moderate attack is most often followed by moderate paralysis, with a greater tendency to a severe than to a slight form. A slight attack shows about the same tendency to be followed by moderate or slight paralysis (11 among 62, severe cases). Cases in which no onset is noted are most often followed by or convulsions. It was classed as moderate when it was severe. The same is true of cases where the affection is attributed to traumatism.

The Distribution of the Paralysis in 628 cases is shown in Table 7. (For comparison the composite group generally quoted is reproduced at the right of the table.)

TABLE 7.

	Authors' Cases.	Duchene; Seeligmuller; Sinkler; Starr.
Both legs	130	184
Right leg	216	134
Left leg	239	183
Right arm	5	30
Left arm	5	23
Both arms alone	0	9
All four extremities	3	51
Arm and leg, same side	15	48
Arm and leg, opposite side	7	10
One arm, both legs	2	15
Abdomen with other paralysis	6	

Our figures show paralysis of one leg to be nearly four times as common as paralysis of both legs, whereas the other figures show it to be twice as common; both sets of figures show paralysis of the arm and leg of the same side to be more common than crossed paralysis. Paralysis of the abdominal muscles was recorded as present in six of our cases and probably was overlooked in the examination of others.

Affection of Individual Muscles of the Leg.—Four hundred and seventy-eight cases where the data were sufficient were tabulated as to the frequency of affection

of the individual muscles in paralysis of the leg. The examination was not made by electricity, but by ascertaining whether or not the functions of a certain muscle or group of muscles could be performed in response to voluntary effort. For example, the patient was told and shown how to abduct the foot; when the motion was being attempted the finger was placed on the peroneal tendons. If the motion was properly performed, the muscle was classed as "normal"; if some contractile power was present, but if motion was imperfect, it was classed as "weak"; if no power of contraction existed it was classed as "paralyzed." For purposes of tabulation the muscles in the lower leg were divided into groups as outlined in Table 8.

TABLE 8.

Anterior	Extensor longus digitorum. Extensor proprius hallucis.	Posterior	Gastrocnemius. Flexor longus digitorum. Flexor longus hallucis.
Internal	Tibialis anticus. Tibialis posticus.	External	Peroneus longus. Peroneus brevis.

The number of cases in which the different groups of the lower leg were affected, no case being entered in two groups, is shown in Table 9.

TABLE 9.

Anterior	92	Anterior, external and internal	18
Internal	40	Posterior and internal	34
Posterior	45	Posterior and external	7
External	31	Posterior, internal and external	8
Anterior and internal	29	Tibialis anticus	95
Anterior and external	27		
Anterior, internal and posterior	14		

The chief practical lesson to be drawn from this analysis is that the internal muscles are affected more frequently than the external, and the anterior more often than the posterior. Of combinations into which the internal muscles entered, there were 238 cases of paralysis against 91 for the external muscles. In the same way there were 180 such combinations in which the anterior entered against 108 for the posterior. The

quadriceps muscle of the thigh was affected alone or in combination with muscles of the lower leg, not counting cases of complete paralysis, in 305 legs, being the muscle most frequently affected in either thigh or calf. The tibialis anticus and anterior muscles of the lower leg came next in frequency, and the short toe flexors were the least likely of all to be affected, frequently persisting in legs otherwise wholly disabled.

The anterior muscles of the thigh are affected much more frequently than the posterior hamstring muscles. When only one hamstring muscle is affected it is more often the internal than the external. The sartorius muscle frequently escapes when the quadriceps femoris is paralyzed, and we have never found the sartorius muscle paralyzed alone. The motor center for the sartorius is given by Edinger as one segment higher than that of the quadriceps.[11] Except in cases of extensive thigh paralysis the sartorius muscle is likely to be found intact, a matter of some importance in the question of treatment, as it may be substituted by operation for the quadriceps.

As to the relative frequency of the affection of internal and external thigh rotators, the fact that the psoas and sartorius muscles frequently escape makes observation of this somewhat inaccurate, for the reason that the latter act as rotators. Therefore, although our figures apparently show a more frequent paralysis of the internal than of the external rotators, and thus confirm general clinical observation, we regard it rather as indicating that the muscular balance was disturbed in that direction than that especial muscles were paralyzed. Involvement of the adductor thigh muscles is far more common than that of the abductor muscles.

Complete Paralysis.—There were 95 instances of complete paralysis of the thigh on one or both sides; 37 cases were recorded as affecting only one side. In 34 of

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11. Bau der nervösen Centralorgane, Leipsic, 1896.

these the paralysis was also complete in the calf of that leg. The right arm was involved once, and the abdominal muscles twice in this group. Fifty-eight cases showed complete paralysis of one side and some involvement of the other. In 26 of these the paralysis was complete in both thighs and both calves. In 31 cases the paralysis was not complete on both sides, in 10 affecting only the quadriceps of the least affected side. In one case there was no note of the muscles affected. Both arms were paralyzed in 2 cases, one arm in 3 cases, the hip was dislocated in 2 cases, and the abdominal muscles paralyzed twice in this group.

Paralysis of the Arm.—Paralysis of the upper arm was much more frequent than paralysis of the forearm, the deltoid apparently suffering most frequently, often in connection with the biceps, triceps, or scapular muscles, or with all of them. Paralysis of the forearm was comparatively uncommon.

In general, the paralysis was more often symmetrical than asymmetrical, roughly speaking, when both sides were affected. In complete paralysis of one leg it has been seen that complete or severe paralysis of the other side existed in nearly two-thirds of the cases (58 double to 37 single). When the paralysis was partial in one leg and the other was affected, the paralysis in the second leg was more likely to be external than internal if the paralysis of the first leg was external.

Deformities.—These are largely, if not wholly, unnecessary, and are of two kinds—(a) static deformities, resulting from superincumbent weight coming on structures imperfectly supported by the paralyzed or weakened muscles or by the weight of some part dragging and stretching the structures; such are valgus deformity of the foot, hyperextension of the knee, dislocation of the hip, scoliosis, dislocation of the shoulder, and some cases of talipes equinus.

The second class of deformities (b) are to be classed as muscular and result from the action of muscles

whose antagonists are paralyzed or weakened. These unopposed muscles cause distortions of one or more joints by their continued pull, which is not antagonized by their paralyzed or weakened opponents, a proper muscular balance being required for joint equilibrium. Such deformities are equinus, varus and calcaneus deformities of the foot and their combinations with those cases of valgus caused by paralysis of the tibials, one or both, flexion deformity of the knee and hip, and cases of scoliosis where the muscles of one side of the spine are paralyzed or weakened. These cases are in all instances accompanied by muscular contractions on the shortened side.

It can be predicted in advance in most instances what a definite muscular paralysis will produce in the way of deformity. For example, in a flail leg unable to bear weight the constant plantar flexion of the foot will induce talipes equinus; if the patient can bear weight on a generally weakened leg a valgus will result from improper support of the foot from the tibial muscles. If the anterior muscles are paralyzed, an equinus deformity will ensue with contraction of the tendo Achillis. If the posterior muscles are paralyzed, the patient will walk on his heel and a calcaneus deformity be present.

From the study of our cases we have formulated the following table of deformities (Table 10) of the foot and their causes:

TABLE 10.

Deformity.	Resulting from paralysis of.
Varus...........	peronei.
Valgus..........	anterior tibial.
	posterior tibial.
	both tibials.
	flexor longus hallucis.
	whole leg (weakened).
	complete paralysis.
Equinus.........	anterior muscles, paralyzed or weak.
	complete paralysis (from dangling).
Equino varus....	anterior muscles.
	(with persistence of flexor longus hallucis).
	anterior and external group.
	paralysis apparently complete
	(probably toe flexors remaining).

Deformity.	Resulting from paralysis of.
Equino valgus....	anterior and internal muscles.
	anterior muscles and weight bearing.
Calcaneus........	posterior muscles.
Calcaneo valgus..	posterior muscles and one or both tibials.

PATHOLOGY.

The modern view of the pathology of anterior poliomyelitis is somewhat different from the view advanced by Charcot, who concluded that the changes in the ganglion cells were primary and that the affection was parenchymatous in character. His conclusions were drawn largely from the observation of cases of long standing in which the terminal results were evident. Of late years the study of recent cases has led to a change in the point of view, and by the majority of modern pathologists anterior poliomyelitis is now regarded as a more or less generalized inflammation of the cerebrospinal axis, and the interstitial character of the process is emphasized rather than the parenchymatous. There are still some observers who hold the original view of Charcot, and in certain recent autopsies the changes in the ganglion cells predominate, but the majority of those who have had an opportunity to examine sections of the cord in recent cases incline to the view that the poison reaches the cord through the arteries supplying it and that the changes are most evident where the blood supply is freest and that the lesions are determined very largely by the distribution of the most important blood supply; namely, the branches of the anterior spinal artery.

In the early stage of the affection there is noticed a congestion of the meninges and of that part of the gray matter supplied by the anterior spinal artery. The vessels are dilated, and the perivascular spaces and the gray matter are filled with leucocytes, small and large mononuclear lymphocytes, which occur especially in the pia and white matter, and polymorphonuclear lymphocytes which are especially evident in the gray matter.

The capillaries are ruptured, and there may be extravasations in the area supplied by the blood vessels. Thrombosis of the branches of the anterior spinal artery may occur. Macroscopically, hyperemia along the vessels and fissures is evident. The ganglion cells of the anterior horns become cloudy and swollen and the nucleus may appear to be granular. Later the protoplasm no longer stains in the customary way, the cell appears swollen and loses its sharp outline, the nucleus becomes faint and some of the dendrites disappear. The grade of involvement of the nerve cell is, in general, proportionate to the nearness of the cell group to the most extensive interstitial changes.

It is probable that, from the stages described, regeneration is possible, but from the severer grade of changes to be next described it is probable that no repair of the cell is possible.

In the next stage the cell appears swollen and irregular. The nucleus is not visible; the dendrites have dropped off; the chromophile granules have lost their regular arrangement, and vacuoles may be present. In the last stage the cell body is reduced in size, perhaps being no larger than the original nucleus. It is granular, and leucocytes have penetrated the pericellular spaces and have encroached on the cell body.

There is in the interstitial tissues a stage parallel to that occurring in the gray matter, in most cases shown by a shrinkage and progressive destruction of the neuroglia. There is hyperplasia and hypertrophy of the neuroglia cells and a diminution in the size of the axone and early degeneration of nerve fibers. There is a secondary degenerative process, an atrophy of fibers in the anterior nerves connected with groups of cells already affected. There is a shrinkage and slight sclerosis in the anterior lateral columns above and below the lesion. It has been commented on by some observers that the pathologic appearances are in most cases severer than the clinical history would lead one to expect, and the

examination of recent cases emphasizes this point of view still further, and it is recognized that parts which were clinically normal in function may be found on microscopic examination to be slightly affected. It has been found on microscopic examination of the pia that in the severe cases there is a widespread inflammation. Foci in the cord correspond in all cases to involvement of the pia on the same level, but inflammation of the pia may occur without the cord involvement. In the severer cases Harbitz and Scheele found an extensive inflammation of the pia over the pons, cerebellum, the cerebrum itself and also more or less inflammation of the brain substance, less intense in the medulla and pons than in the cord. In milder cases these investigators found fat granule cells in the walls of blood vessels of the medulla, occasionally in those of the basal ganglia, and in some cells in the gray cortex.

In a word, the process seems to be a widespread inflammation, with especially marked changes in the anterior cornua of the cord. Although the lesion is most marked in the anterior horns, the central gray matter is, in some cases, affected, explaining the occurrence of pain and subsequent interference with the growth of the limb, the central gray matter being especially associated with growth.

It is not unusual in severe cases to find also some involvement of the posterior horns which with the meningeal inflammation also explains the occurrence of pain in so many cases in the acute stage of the disease. Following the acute stage there is a gradual shrinkage of the entire area of the anterior horn by the formation of the scar tissue inevitably following the process described. This leads to a collapse inward of the white columns surrounding the affected area in the gray matter, and there is also an atrophy in the nerves issuing from the horns through these columns to the anterior roots. The anterior nerve roots involved are diminished

in size and there is a degeneration of the fibers composing them. The widespread distribution of scar tissue and the mechanical influence of the interstitial tissue thus affected, on the neighboring cells is a factor occasionally spoken of as predisposing to further destruction of the motor cells. In old cases the outlines of the tracts are indistinct, and microscopically one finds the vessels sclerosed in all their coats and the group of ganglion cells replaced by fibrous tissue rich in nuclear cells.

In short, the cord at the affected level appears shrunken on the diseased side, the changes being particularly marked in the anterior horn. In some cases the changes in the gray matter are predominant and but little interstitial change can be found; in other cases the reverse is true. Some writers have assumed the existence of two distinct types of the affection, but, whatever the theoretical origin of the disease may be, the practical conclusion for the surgeon is, "That in the lesion of the great multipolar nerve cells of the anterior horns the striking character of the affection and its sequelæ are manifest" (Schmaus).

The changes in the affected muscles vary between severe parenchymatous and interstitial changes to a wasting of whole muscles, depending on the intensity and duration of the affection of the ganglion cells. This atrophy apparently does not begin at once, being absent in a case of Jagic[12] five days after the attack, but fatty degeneration without atrophy was found by Redlich[13] ten days after the attack. It is, however, seen from three to four weeks after the attack.[14] Later in the history are to be found fatty, waxy, and granular degeneration. In the latest stages these degenerative changes are represented by the replacement of the muscles by thin bundles or layers of connective tissue. The

12. Wien. med. Wchnschr., 1899, pp. 9-10.
13. Wien. klin. Wchnschr., 1894, p. 287.
14. Lorenz: Die Muskelerkrankungen, Vienna, 1904, p. 574.

muscle nuclei remain normal or are increased in size. In operations on the living, where the disease has been of considerable duration, normal muscles are bright red, disused or partly paralyzed muscles are rose colored, and wholly paralyzed muscles are yellowish in color.

The pathologic conclusions presented above have been largely obtained from the works of Starr,[15] Schmaus,[16] Harbitz and Scheele,[17] Hoch,[18] Pretorius,[19] Goldscheider,[20] and Lorenz.[21]

TREATMENT.

The matter of treatment will be discussed only in general terms, for no tabulation of results in so large and varied a group of cases would be practicable or of great value.

Stage of Onset.—The stage of onset represents an acute hematogenous myelitis. Quiet in bed is essential, and beyond this it is doubtful if much is accomplished by the administration of ergot and similar drugs or by blisters or other counter irritants applied to the back. As there is a possibility that the absorption of toxins from the intestinal tract is an important factor, it would seem reasonable to empty the intestines at the onset by catharsis in all cases. From the onset paralyzed limbs should be supported in a normal position, and muscular dragging and stretching should be avoided. Pain and sensitiveness, when present, generally last only for the first few days and will not long prevent the use of supports. A foot can be supported at right angles to the leg by splints of wood, tin, or plaster of Paris. It is doubtful if the use of massage and electricity in the first days after the attack is ad-

15. Organic and Functional Diseases of the Nervous System. Lea Bros., Philadelphia, 2d ed.
16. Vorlesungen über die pathologische Anatomie des Rückenmarkes. Wiesbaden, 1901.
17. The Journal A. M. A., Jan. 25, 1908.
18. Hoch: Jour. Nerv. and Ment. Dis., September-October, 1905.
19. Centralbl. f. Kinderh., new series 58, 1903, p. 193.
20. Deutsch. med. Wchnschr., 1893, No. 19.
21. Die Muskelerkrankungen, Vienna, 1904.

visable. It would seem wiser to allow from one to three weeks for nerve centers to quiet down before stimulating their peripheral connections. How long the period of rest to the limbs should be carried out can not yet be stated, but will probably be answered definitely by the results observed in the recent New York epidemic.

The Stage of Established Paralysis.—A localized hematogenous myelitis has attacked the cord and has destroyed more or less at random certain areas of spinal nerve centers. Unless the cord lesion has been extensive (for the reasons discussed in the opening section) the chances are rather against the total destruction of all the centers and associations of any large number of muscles, some centers or associations having perhaps escaped.

It is, therefore, obvious that in the stage of established paralysis, whether early or late, it is important to prevent unnecessary muscular deterioration and to utilize, so far as possible, the unaffected cells in partly affected centers.

In other words, to prevent (a) muscular stretching, (b) muscular disuse, which are both obviously harmful to the well-being of the muscles, and (c) stimulate to functional activity muscles partly paralyzed or simply disused.

It is coming to be the experience of those who deal with the later stages of infantile paralysis, and it has been particularly evident in this series of cases, that there exists in many paralyzed limbs a possible amount of muscular power that is not suspected and will not be available unless cultivated and developed. For example, it has several times been our experience in this series to examine cases of paralytic talipes equinus of long standing where there was no power in the anterior muscles of the lower leg. The tendo Achillis has been divided, and the foot put up at a right angle in plaster

for three or four weeks. When this plaster has been removed, the anterior muscles have been found to functionate and from that point on to have recovered power. They had been stretched and out of balance before the operation; when properly balanced and allowed to shorten they possessed function.

The absence of function in a muscle or group of muscles does not necessarily mean paralysis, even in the later stages of the acection, as long recognized by the neurologists. This paper becomes, therefore, a plea for the more persistent attempt to use other measures in addition to braces and operations in the treatment of these cases.

(*a*) *Prevention of Muscular Stretching.*—The harmful effect of stretching muscles in paralyzed limbs was dwelt on forty years ago by C. F. Taylor,[22] but has not been sufficiently remembered. He wrote as follows:

Any position of a limb which allows the extensor muscles to become shortened must inflict a worse damage on the flexors by keeping them extended till they lose their remaining irritability and become degenerated. Now, we have another fact connected with these cases when they have arrived at the stage of deformity, viz: The difficulty of treatment consists much less in relaxing shortened muscles than in giving tone and strength to their antagonists—the lengthened and weakened ones. Indeed, it is this, in the destruction of all remaining muscular irritability, and in many instances the destruction and entire loss of the substance itself of the expanded muscle, which constitutes the principal anxiety in treating this class of deformities. As this important consideration has been many times neglected, if not entirely lost sight of, let us consider the effect of simple extension on the power and functions of muscular tissue in its healthy state.

In reference to this the following propositions are believed to be true, viz.:

First. To retain a healthy muscle in an expanded state for a certain length of time is to diminish or destroy its irritability and contractible force.

Second. To extend a muscle while in the act of contracting, that is, to overcome it, is, at once, to destroy its irritability and force.

22. Infantile Paralysis, Philadelphia, Lippincott, 1867.

Having shown that position of the limbs alone is sufficient to cause deformity even in the healthy subject, it only remains to inquire: Is this actually the case in infantile paralysis? The reply must be affirmative.

The importance of supporting the limb during the early stage in a correct position has been alluded to. In the stage of established paralysis orthopedic apparatus is intended not only to make locomotion possible, but to prevent deformed positions in standing and walking and with this to prevent muscular stretching. The foot should be neither in valgus, calcaneus, or varus when weight is borne, but supported in the proper plane at right angles to the leg. The knee should be neither in a flexed nor hyperextended position in weight-bearing, but straight. A very good general rule for the use of supporting apparatus is that it should be used when weight-bearing induces a deformed position in the foot or knee, because such deformity not only leads to permanent distortion of the bones, but is necessarily accompanied by prolonged muscular stretching and leads to contraction deformity of the antagonistic, not stretched muscles.

(*b*) and (*c*) *The prevention of muscular disuse and the stimulation of nervous centers* in the cord in partially destroyed groups are accomplished together by the same measures. For a muscle to lie idle and not to contract is bad for it whether it is paralyzed, or partially paralyzed, or not paralyzed at all. It will deteriorate locally and its functional cord center will not be stimulated to establish new associations or develop any latent power. But as a prerequisite to all treatment of this kind it must be assumed that the foot is properly supported by apparatus in walking, if without it it falls into a position of deformity. (The use and function of supporting apparatus is discussed in text-books on orthopedic surgery.)

Having thus supported and held the paralyzed limb in a position fit for functional use, massage and elec-

tricity are to be regarded as measures to improve the condition of the muscles and to lead toward functional use of partially paralyzed, stretched or disused muscles. Of themselves they are not curative or especially helpful, except in so far as they promote muscular well-being and lead to muscular contractibility.

Active muscular contraction or muscle training is, in general, the most universally applicable therapeutic measure at our command and one insufficiently appreciated. Having worked with massage or electricity or both, for the development of the muscle or muscles an attempt should be made as soon as it becomes possible, to get the partly affected muscular group to contract in response to a voluntary impulse, at first being satisfied with only a quiver in the fibers at the attempted movement, but later affording aid in the attempted movement by the hand, by some improvised apparatus, such as a strap or bandage, or by the use of some mechanical apparatus, such as those of the Zander system, those used so extensively in Germany, or by some simpler form. In short, the effort is to be made to make the partially affected muscles contract without being overweighted and, having learned to contract, to educate them to use more and more power until they perform useful function.

To repeat this most important point, mechanical or conservative treatment should consist not only in supporting the paralyzed limb by an adequate and acurately fitted brace, but should push on to the develoment of muscles apparently paralyzed, but really with a possibility of function.

Tendon Grafting or Anastomosis or Transfer.[23]—Although there were 120 cases of tendon transfer in the present series, they will not be analyzed here, for the reason that a report on this subject has already been made from the hospital and because the limits of the

23. Assn. franç. de chir., 20th cong., 1907, pp. 380-574.

paper are such that it is impossible to consider every phase of the subject, and, as this part of the subject is adequately treated in current literature, we have chosen rather to devote our space to those aspects of the matter which have received less attention. The following practical conclusions have, however, been reached from the study of these cases:

1. It is important to remove deformity by a preliminary operation when it is present to any considerable degree and not to correct the deformity and perform the tendon transfer at one operation.

2. The operation should not be performed on very young children.

3. Periosteal implantation yields better results than when tendons are united to tendons.

4. Simple operations are more satisfactory than complicated ones.

5. It is not advisable to turn sharp corners with transferred muscles, but to secure as straight a line as possible of muscular pull from origin to insertion.

6. The substitution of small muscles for large ones is likely to be unsatisfactory, e. g., one of the peroneal muscles is rarely a satisfactory substitute for the gastrocnemius.

7. Tendons must be inserted on the stretch and the foot maintained for some weeks in a position of overcorrection.

8. The use of silk tendons has proved practicable and satisfactory.

9. Finally, the most striking conclusion that has been impressed on us is that the after-treatment is as important as the operation, if a successful result is to be obtained.

To perform a tendon transfer, fix the leg in plaster for some weeks, until muscular atrophy has become marked, and then to allow walking unprotected is bad treatment. Unless the operated leg is massaged from

the sixth week on and the newly transferred muscle is trained to its new function shortly afterward, and unless this massage and training are carried over some weeks, the best results can not be expected. No matter how good the operation, it must be followed up or the operation of tendon transfer will be regarded by the individual operator as a much overestimated procedure; if, on the other hand, he performs a sound and reasonable operation, and has his patient properly treated over a period of about six months, he will find it, in a large proportion of cases, one of the most satisfactory procedures in operative surgery. No importance can be attached to published results of tendon grafting unless there is published at the same time an account of the after-treatment. If it is lacking, poor results are explained.

The method followed at the Children's Hospital has been as follows: The plaster put on at the operation is worn for six weeks. It is then split, removed for massage, and reapplied. About two or three months after the operation a brace is applied which shall support the foot in a position to relieve strain on the transferred tendon, and muscle training is begun. Walking is allowed from three to six months after operation in this brace, when the tendon seems to possess enough power to warrant it, and the brace is discontinued when circumstances warrant it. At the Hospital Out-patient Orthopedic Clinic a department for massage and muscle training has proved a necessity and is devoted wholly to the treatment of infantile paralysis, both operative and non-operative. It has proved of such great use that it is planned to extend it in the near future and add simple mechanical appliances to amplify the work.

Arthrodesis.—The operation of arthrodesis was performed fifty times in this series, but will not be dwelt on in detail here, for the same reasons given in speak-

TABLE 11.

Name of Observer.	Variety of Paralysis.	Operation.	Result.
1. Peckham[24]	Peroneal	Int. into ext. popliteal	Marked improvement.
2. Young[25]	Valgus	Branch to ant. tib. into musc. cut	Great improvement.
3. Taylor[26]	Equinus	Ext. into int. popliteal	More power.
4. Taylor	Equinus	Ext. into int. popliteal	Can flex foot.
5. Spiller and Frazier[27]	Ant. tibial	Ant. tib. into musc. cut	Return of normal power.
6. Spiller and Frazier	Peroneal	Ant. tib. into musc. cut	No improvement.
7 Murphy[28]	Talipes	Ext. popl. into int. popl	Improvement.
8. Murphy	Peroneal	Musc. cut into ant. tibial and tenoplasty	Time too short for report.
9. Hackenbruck[29]	Equinus	Ant. into ext. popl	No result—Keloid.
10. Hackenbruck	Equino-varus	Ant. into ext. popl	No result—Keloid.
11. Hackenbruck	Equinus	Ant. into ext. popl	Excellent result.
12. Tubby[30]	Equino-varus	Nerves of gastrocn. soleus into ext. popl	Return of movement.
13. Tubby	Equino-varus	Nerves of gastrocn. soleus into ext. popl	Return of movement.
14. Tubby	Equino-varus	Ext. into int. popl	Unsatisfactory.
15. Spitzy[31]	Anterior and exterior	Ext. into int. popl	Good result.
16. Spitzy	Obstetr. paral	Median into radial	Remarkable result.
17. Tubby	Erb-Duchenne	Ext. into int. branches of brachial plexus	No definite result.
18. Harris[32]	Deltoid	Fifth into fourth cerv. nerve	Good result.
19. Peuguiez[29]	Circumflex	Radial into circumflex	Too recent.

24. Providence Med. Jour., January, 1900, p. 50.
25. Am. Jour. Orthop. Surg., I, 27.
26. New York Med. Jour., 1906.
27. THE JOURNAL A. M. A., Jan. 21, 1905.
28. Surg., Gynec. and Obst., April, 1907.
29. Assn. franç. de chir., 20th cong., 1907, p. 444.
30. Brit. Med. Jour., 1906.
31. Ztsch. f. Orthop. Chir., 1905.
32. Tr. Clin. Soc., London, 1905.

ing of tendon transfer. The following conclusions have been reached from the study of these cases: The operation in the ankle joint is useful in properly selected cases. It has not been used in the knee. It has been both successful and unsuccessful in the hip, and fairly satisfactory in the shoulder, although here tendon transfer is advisable when possible. The use of arthrodesis in the ankle by means of silk has proved satisfactory and is preferable in children to the more destructive operation of removing the joint surface. The cutting away of the joint surface in young children is, at times, followed a few years later by a distortion of the foot into a position of varus. The operation should not be performed in the ankle on children much under the age of puberty.

Nerve Anastomosis.—The question of the value of nerve anastomosis is still *sub judice* and the operation was performed only once, with negative result, in the series reported. About 20 cases have been reported in the literature, which are given in Table 11, which presents the results of available recorded operations performed for paralysis of the limbs. The brilliant results reported in some of the cases would seem to promise a future for the operation.

CONCLUSIONS.

Infantile paralysis is a less formidable affection than is generally believed, partial paralysis is common, disused and stretched muscles appear to be paralyzed, but possess a possibility of function. In addition to mechanical treatment, an attempt should be made by massage, electricity and especially by muscle training to wake to activity the remaining cells in partly destroyed groups and thus to secure muscles which perform function. After tendon transfer, the development by muscle training of the transferred tendons is essential to good results, and without this the percentage of failure will be large.

DISCUSSION.

Dr. Harry M. Sherman, San Francisco: The one part of the paper which I am inclined to discuss is that relating to tendon transplantation for the correction of deformities incident to the paralysis. So far as the technic of the operation is concerned, I prefer the Langer method, which substitutes for the tendon of the paralyzed muscle, which is a paralyzed tendon, a silk tendon, which is quite as good as a normal tendon, if it is large enough and properly fastened to muscle and bone. The same is true of silk ligaments.

In dealing with the matter of paralyzed muscles we have in the first place to remember that no one muscle can do the work of two or three muscles, and if we attempt to make it we overload it. Moreover, if we move the attachment of a live muscle to the insertion of a paralyzed muscle we weaken the limb by the loss of the live muscle in its normal place. So that at the end we can not expect a normal limb, but can only look for a limb weaker in more than one of its components. In general we select to replace paralyzed ones those muscles which have a similar and nearly synchronous action with the paralyzed. If we are forced to make less obvious selections, as taking a flexor to do extensor work, we are not only overloading the muscle, but we are complicating the condition and lessening the expectation of a satisfactory result. In brief, no matter how we rearrange the muscles we have a limb weaker than normally in many of its components. The rearrangement, however, may tend to prevent the development of deformity, or the redevelopment of a deformity which has once been corrected, and with the aid of some special shoeing or of a simple concealed brace a gait may be possible with a minimal amount of limp.

In legs which are below par as regards their nourishment—for the trophic nerves are implicated with the motor nerves, and the motor nerves have been paralyzed—in these cases it seems not unlikely that growth may be stimulated by the use of the congestive bandage, applied according to the method of Bier. In two or three of my cases which I have been able to watch, and in which I resorted to this method, the paralyzed leg is growing at a little more rapid rate than its mate on which no congestive bandage has been placed. It is possible that thus a weak leg may be converted into a somewhat stronger one.

Dr. E. H. Ochsner, Chicago: Dr. Lovett calls attention to a large series of cases observed by one group of men in one locality. This point is of the utmost importance. Six hundred cases thus studied allow of deductions of far greater value than can be drawn from a much larger number of cases observed and classified by many men in various parts of the

world. Again, the distribution of the groups of motor cells and the distribution of the circulation of the cord is a subject which is deserving of much attention, because it has an important bearing on the treatment of these cases.

I agree with Dr. Lovett most thoroughly that we should pay especial attention to the intestinal tract in the early treatment of these cases. Unfortunately most of these cases are not definitely diagnosed during the first few days of the illness, but whenever the diagnosis is obscured and when there is a possibility of a beginning poliomyelitis anterior I would go even a step further than has Dr. Lovett and would contend that the bowels should be thoroughly evacuated by a large dose of castor oil, so as to render the intestinal canal as free as possible of all toxic material. I fully agree with Dr. Lovett that all deformity should be overcome before any attempt is made at tendon transplantation and also that we should not attempt to do too much at one time. I believe that it is very much safer to do one or two transplantations first, then observe what coordination will do, and help out with a secondary operation if necessary. I have repeatedly seen cases in which I felt convinced that too much had been done at the first operation. When a case of poliomyelitis comes to me for treatment there are always two things which I try to accomplish: one is the re-establishment of muscular equilibrium and the other is proper coordination. When the operative procedure is completed the flexors should be exactly as strong as the extensors, the abductors as strong as the adductors, and if this ideal can be accomplished it is surprising with how little innervation one can still secure a reasonably useful limb. It is this point that I especially want to emphasize.

The general practitioners and neurologists in looking over their cases if they find the muscles very weak are very apt to conclude that an operation is not indicated. It is not so much a question of the innervation and development of the muscles, provided there is some innervation, as it is a question of whether muscle equilibrium can be re-established. I have found that after extensive operations some patients find it impossible to coordinate, to adjust themselves to the new conditions. If in such a case one will incase all of the joints in light but rigid plaster of Paris casts, if now one joint is let out of the cast the patient will learn to coordinate this group of muscles, and if one joint after the other is let out one can often get very good results in apparently almost hopeless cases.

Dr. R. W. Lovett, Boston: The two points that I wish particularly to make are: 1. The fact that a muscle will not functionate does not necessarily mean that it is paralyzed. It may be stretched and it is possible that it may be made

useful to the patient if it is attacked properly. 2. Tendon-grafting alone will not do. The after-treatment is very important. To do tendon-grafting and to put up the leg in plaster for six or eight weeks and to allow the patient to walk is to invite a poor result. It is being recognized everywhere that the after-treatment is just as important as the operation, and that much of the criticism of the operation is wholly due to the absence of after-treatment.

RESULTS OF THE TRANSPLANTATION OF BLOOD VESSELS, ORGANS AND LIMBS.

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INTRODUCTION.

The idea of replacing diseased organs by sound ones, of putting back an amputated limb or even of grafting a new limb on a patient having undergone an amputation, is doubtless very old. The performance of such operations, however, was completely prevented by the lack of a method for uniting vessels, thus re-establishing a normal circulation through the transplanted structures. The feasibility of these grafts depended on the development of vascular surgery.

Although the first attempt of arterial suture was made very long ago by Hallowell, the results were negative for a great many years. It became a dogma that thrombosis was the necessary consequence of a vascular suture. Nevertheless, some experimenters were able to obtain, from time to time, union of severed vessels without thrombosis. The history of vascular surgery is too well known to need repetition. It recently reached the active stage of its development with the experiments of Murphy in Chicago and of Payr in Gratz. Murphy united the arteries by invagination and suture, while Payr used a magnesium tube. The remarkable experiments performed in 1903 by Hoepfner with the method of Payr gave an illustration of what could be obtained in vascular surgery by a proper method.

In 1901 I performed some anastomoses of blood vessels by Payr's and Murphy's methods. The use of magnesium tubes appeared to be too dangerous and not adaptable to every case. It was soon given up. Murphy's method was progressively transformed. It was found that invagination is unnecessary, and that arteries united end to end by a simple continuous suture made under certain conditions, heal without thrombosis or hemorrhage. Finally, a very simple method of circular suture was developed, which, used in France and at the University of Chicago, in the laboratory of Dr. Stewart, and afterward at the Rockefeller Institute for Medical Research, has given me many excellent results. The experiments of Watts, in Johns Hopkins University, showed also that the arterial anastomoses by circular suture are almost always successful. At the clinic of Garre, in Breslau, Stich and Makkas used the same method with similar results. Fred T. Murphy in Boston, MacClure in Baltimore, Ward in New York, Guthrie in St. Louis, Frouin in Paris, and many others obtained excellent union of several arteries and veins by this same procedure. From the results of all these experiments it appears that vessels sutured under certain conditions heal very easily, and that no thrombosis occurs as long as the operation is aseptic and the union of the vascular ends accurate.

We know also that the results are durable. A dog on which I performed with Guthrie a cross anastomosis of the carotid artery and of the external jugular vein in August, 1905, was still living in May, 1908, and the circulation goes on through the arteriovenous anastomosis. Several animals, operated on more than a year ago at the Rockefeller Institute, are alive with a normal circulation through their anastomoses. Besides, the examination of the anatomic results show that the scar of the severed vessels is, in many cases, so small that, after a few months, it is hardly discernible. When the

vessels are of about the same caliber, as, for instance, the internal jugular and the common carotid artery of some dogs, or both common carotid arteries, the anastomosis, after fifteen days, is easily recognizable to the palpating finger by a narrow circular induration of the vascular wall. Sometimes, when a very fine thread is used, this induration may be very slight. On opening the vessel, a narrow circular line is seen on the intima. It is smooth and glistening and a few stitches are often apparent (Fig. 1). When the suture has been carefully done, it may happen that, after seventeen or twenty days, no stitches at all are seen. On a renal artery examined a little over two months after the suture (Fig. 13) it was impossible to localize exactly the position of the venous anastomosis. The arterial anastomosis was represented only by an indistinct line crossing the intima and hardly discernible. There was not the slightest modification of caliber of the vessel at the level of the anastomoses.

If the anastomoses are less carefully made, or if the caliber of the vessels are very different, a little fibrin deposits itself on the line of the union. It does not interfere with the circulation, when the vessels are of sufficient size, but the anastomoses are less smooth and the intima presents at their level a cicatricial appearance after a few months (Fig. 6). After six months it may happen that no evidence of anastomosis is seen, even when the vessels are of different caliber and of different nature (Fig. 8).

One year, and more than one year after the operation, the results were found excellent. One year ago the central end of the left carotid artery of a fox terrier was united to the peripheral end of the right carotid artery. A few weeks ago the vessel was dissected. The location of the anastomosis was recognized by a slight adhesion of the artery to the vagus nerve. But after extirpation and longitudinal opening of the vessel it was

almost impossible to localize the anastomosis. No modification of caliber and no scar were seen on the intima. In one point only, corresponding probably to a knot of the thread, the wall was a little hardened and had lost a part of its elasticity. But this difference is so small that it is not discernible by simple inspection (Fig. 2).

Another specimen, taken from a dog one year and two months after the operation (Fig. 7), shows that from a gross anatomic standpoint all evidence of the anastomosis by the circular method may disappear after a few months. Of course my results are not all so satisfactory. The anastomosis often remains discernible. From a functional standpoint it is of no importance. It must be known also that if the arterial sutures give excellent results when correctly applied, a fault of technic, even very slight, can be followed by obliterative thrombosis. Success depends much less on the way of handling the needles or passing the threads than on the knowledge of the causes which are able to determine a deposit of fibrin on the wall of the vessel on the line of anastomosis, and of their removal. Nevertheless, when the vessels are of sufficient caliber, accidents seldom occur. Therefore, this method of anastomosis may be employed for more complicated operations, the transplantations of vessels, organs, anatomic regions and limbs.

I. TRANSPLANTATION OF VESSELS.

A segment of an artery or vein can be transplanted between the cut ends of an artery or a vein, between two regions of the circulatory apparatus, and even between a serous cavity and a vessel. For instance, in some cases of ascitis it would be useful to establish a permanent drainage of the peritoneal cavity by suturing a piece of a valvular vein between the peritoneum and a large vein. An operation of this kind has already been attempted successfully in Africa by Ruotte. He cut the saphenous vein and sutured its peripheral end

to the peritoneum in a case of chronic ascitis. The ascitis disappeared. In Dr. Harvey Cushing's laboratory MacClure attempted to graft a segment of vein between the dura mater and the external jugular vein. In case of hydrocephalus this would establish a permanent drainage of the arachnoideal spaces into the venous system. Lately Payr has performed a similar operation on a hydrocephalic child. He tried to direct the cerebrospinal fluid into the longitudinal sinus by a venous transplantation.

The graft of a segment of vein between branches of the portal vein and the vena cava would act as a substitute for Talma's operation. However, the main application of the vascular transplantations will be, probably, the re-establishment of the circulation through an artery of which a segment has been accidentally or surgically destroyed. The ideal method would be to transplant between the cut ends of the artery a fresh segment of human artery. But this is not easily practical. Therefore, I attempted to determine whether or not a segment of vein, or a segment of artery preserved in cold storage or an artery from an animal of another species can be used safely.

The Transplantation of a Segment of Artery.—This was performed for the first time in 1896 by Jaboulay. He thought that this method could be applied to the treatment of aneurisms, but the anastomoses were imperfect and in every case thrombosis occurred. Nine years later Hoepfner performed successfully the transplantation of segments of arteries by using the method of Payr, and in a remarkable series of experiments demonstrated the possibility of transplanting arteries without the occurrence of thrombosis. In 1905, in Chicago, and afterward in New York, I applied to the transplantation of arteries the circular suture and found that this method gives excellent results, even when the vessels are of different caliber. Watts in Baltimore, Stich and Makkas in Breslau, MacClure in Baltimore,

Wood and Ward in New York, obtained similar results. The clinical and anatomic results of this operation are actually well known.

The transplantation of a segment of artery on an artery of another animal of the same species is ordinarily successful when the vessels are of sufficient caliber and the anastomoses are performed correctly. If the vessels are of different size, and consequently the exact approximation of the intimas is difficult, fibrin can deposit itself on the line of suture. Therefore, in case of great difference of caliber, it would be prudent to reduce the diameter of the end of the larger vessel by a V-shaped resection. The inferior mesenteric artery, with a little piece of aorta, was extirpated in a dog, and a segment of the aorta itself resected. Between the ends of the aorta a segment of the aorta from another dog was sutured, and on the wall of the new vessel the inferior mesenteric artery was grafted. There was a considerable difference of caliber between the two vessels. When the vessel was examined eight days after the operation (Fig. 3) there was a slight deposit of fibrin around the lines of suture, but this parietal thrombosis did not interfere with the circulation.

When the vessels are of the same caliber the surface of the anastomoses remain smooth and, after a few months, the transplanted segment has absolutely the same appearance as the normal vessel. There is no modification of its size, no stenosis or dilatation of its lumen, and even the wall has kept its elasticity and its normal thickness. The carotid of a dog was examined three months after the transplantation of a segment of artery. The transplanted segment was exactly similar to the other parts of the artery. There was no modification of caliber. Its elasticity was normal. The only evidence of the operation was two whitish transverse lines on the intima (Fig. 4).

The histologic examination of transplanted arteries shows that the wall does not undergo marked modifica-

Fig. 1.—Arteriovenous anastomosis of the common carotid artery and the internal jugular vein of a dog; fifteen days after operation.

Fig. 2.—Arterio-arterial anastomosis of the central end of the left carotid artery to the peripheral end of the right carotid; one year after the operation. Scar almost invisible.

Fig. 3.—Transplantation of a segment of aorta into the abdominal aorta; eight days after operation.

Fig. 4.—Transplantation of a segment of carotid into the carotid artery; three months after operation.

Fig. 5.—Segment of external jugular vein transplanted on carotid artery; fifteen days after the operation.

Fig. 6.—Segment of external jugular vein transplanted on carotid artery; eight months after operation.

Fig. 7.—Segment of carotid preserved in cold storage for ten days and transplanted into the carotid artery; fifteen months after the operation. Anastomosis completely invisible.

Fig. 8.—Transplantation of a fresh segment of carotid of dog into the abdominal aorta of a cat. The transplanted segment is very much dilated; the anastomoses are invisible.

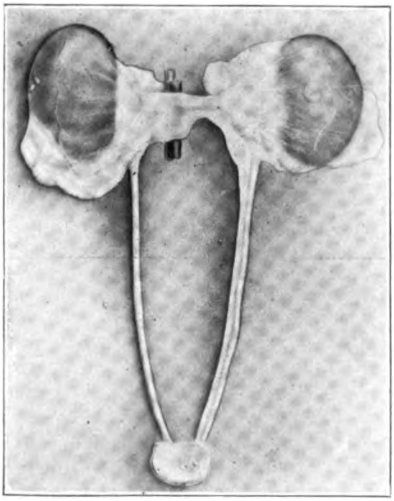

Fig. 9.—Kidneys, segment of aorta and vena cava, ureters and part of the bladder extirpated from first cat.

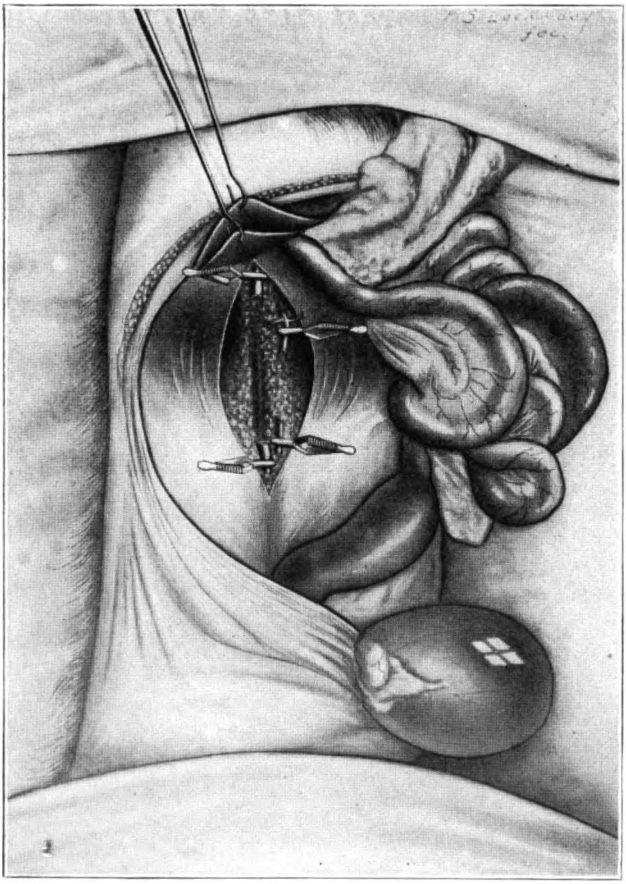

Fig. 10.—Second animal ready for the reception of the anatomic specimen (Fig. 9). The aorta and vena cava have been cut and their ends are ready for the anastomoses.

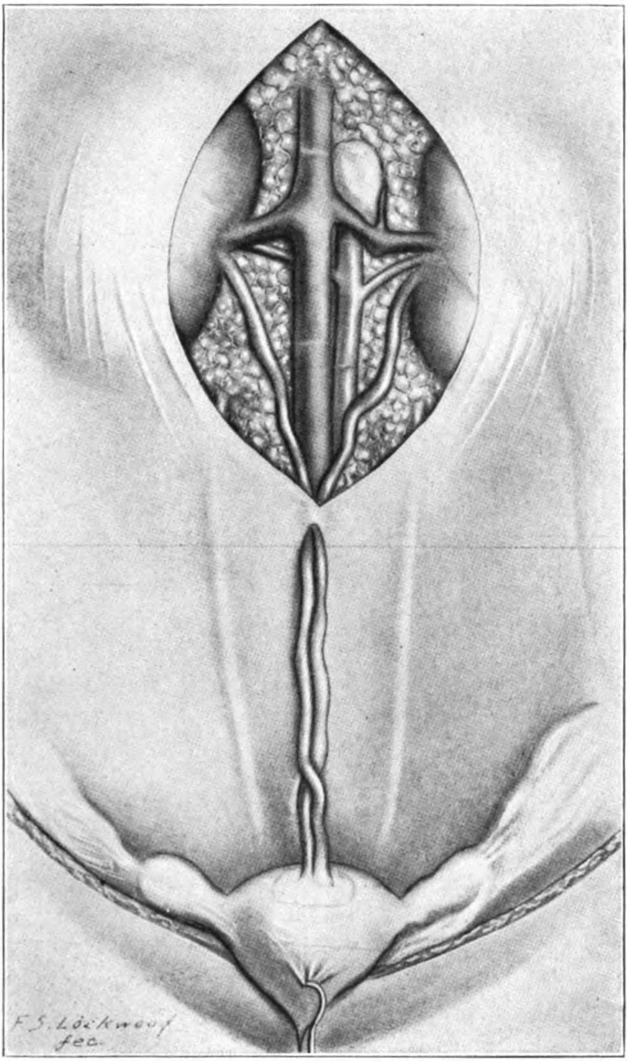

Fig. 11.—Specimen showing the transplanted kidneys after healing of the aortic and caval anastomoses and of the suture of the flap of the bladder.

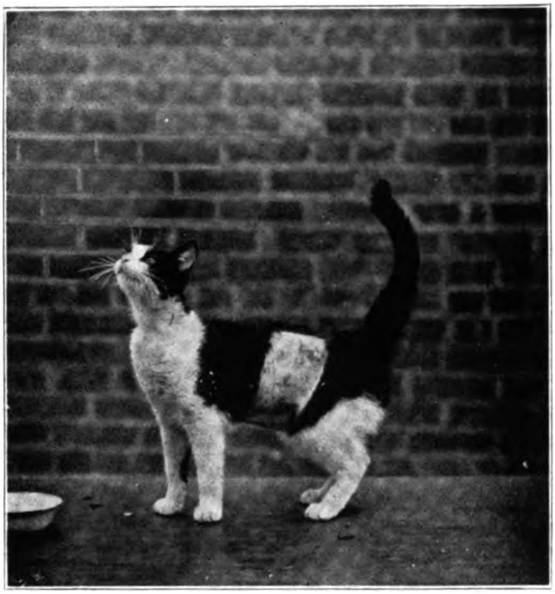

Fig. 12.—Cat looking at piece of meat on the twenty-first day after the double nephrectomy.

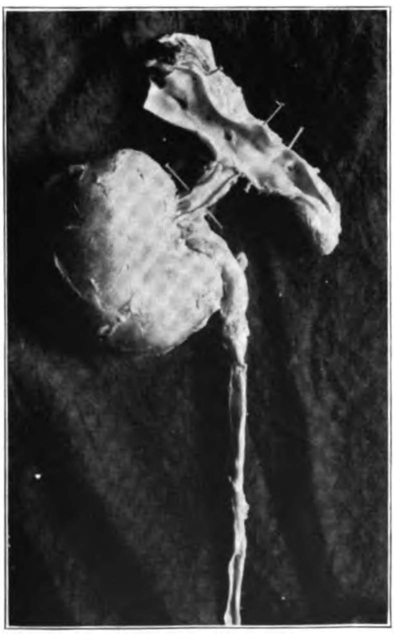

Fig. 13.—Replanted kidney, two months after the operation. The aorta and renal artery have been opened longitudinally. The scar of the arterial anastomosis, located a few millimeters from the bifurcation of the renal artery, has become almost completely invisible.

Fig. 14.—Extirpation of both kidneys. Replantation of one kidney; four months after the operation.

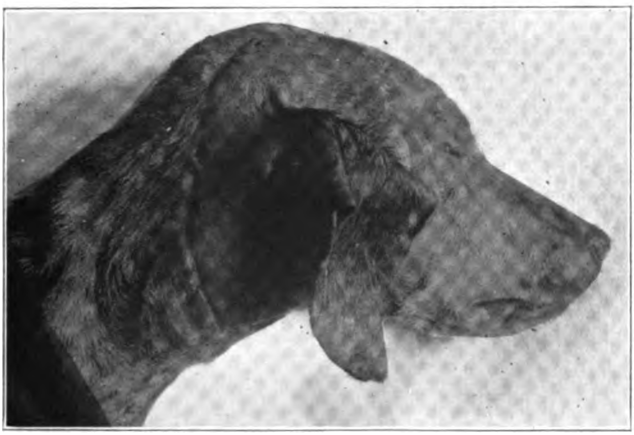

Fig. 15.—Transplantation of the auricle, scalp, cartilaginous auditory canal, etc.; three weeks after the operation.

Fig. 16.—Transplantation of the leg from one dog onto another. The new leg has united by first intention and the scar is visible; twenty-two days after operation.

Fig. 17.—Specimen showing the fibrous callus uniting the tibia of the new leg to the upper part of the tibia of the host.

tion. Wood has studied the vessels during the seventy days following the operation. The elastic and muscular fibers of the media remain normal. There is a little increase of the interstitial connective tissue. The intima is sometimes a little thickened. In some places the endothelium is absent, in some others it is normal. Seventy days after the operation it is difficult to find a difference between the normal and transplanted parts of the vessel. These results are easily explainable, for the nutrition of the transplanted arterial segment undergoes very little change.

Sometimes immediately after the transplantation the vasa vasorum may be seen injected with blood. Stich has also observed this phenomenon. It is probable that very soon the vasa vasorum anastomose with the vessels of the surrounding tissues. Even when the periadventitial tissues and the adventitia have been resected, the circulation of the wall is quickly re-established. Hoepfner demonstrated long ago that the denudation of an artery does not interfere with its nutrition. On the other hand, the histologic study of the growing of blood vessels into small grafts of tissue shows how quickly new vessels are developed. Christiani found that three days after the operation new capillaries came from the surrounding tissues toward the graft and entered it. Therefore, it is reasonable to believe that in case of arterial transplantation, the circulation is re-established through the vasa vasorum in a very few days. It explains why the anatomic conditions of the vessel remain normal.

The remote results are excellent. A dog, into whose aorta a segment of aorta from another dog had been transplanted, was living and in good health nine months after the operation, and the femoral pulse was normal. These results show that segments of fresh arteries transplanted from an animal on another animal of the same species remain practically normal from a physiologic and histologic standpoint.

Transplantation of Veins.—Unfortunately this operation would not be very practical on man, for it is difficult to get fresh pieces of human arteries. If the veins could act as a substitute for arteries, the problem of the treatment of large wounds or of resection of arteries would be solved, for it is always possible to get venous material from the patient himself. The first attempt of transplantation of a segment of jugular vein into the carotid artery of a dog was made by Gluck in 1898, but thrombosis occurred. In 1903 Exner performed six experiments of the same character, but in all cases thrombosis took place. He thought the failure was due to the poor nourishment of the transplanted vessels, resulting from disturbance of the vasa vasorum. In the same year Hoepfner, using the magnesium tubes of Payr, made ten transplantations of veins on arteries, with constant negative results.

In 1905 I succeeded with Guthrie in transplanting segments of jugular veins into the carotid artery and found that the vein quickly undergoes structural changes, consisting chiefly of the thickening of its wall. Stich and Makkas observed the same results. Watts succeeded also in transplanting segments of jugular on the carotid. I obtained excellent results in the transplantation of the vena cava into the aorta, operations which had been attempted with negative results by Goyanes in Spain. From all these experiments it is possible to know the anatomic evolution of a piece of vein transplanted on an artery.

The transplantation is often successful, but much less constantly successful than the transplantation of arteries on arteries. Thrombosis occurs more frequently, and generally during the first days following the operation. This is due, perhaps, to the difference of caliber of the vessels generally used, jugular vein and carotid artery. The approximation of the intimas is difficult, fibrin deposits itself on the foldings of the vein, and can produce, under certain conditions, obliterative

thrombosis. When the artery and the vein are of the same caliber, the results are much better. I performed twice the transplantation of the vena cava into the aorta and in both cases the healing was perfect. It is probable that the results of the venous transplantations could be as good as those of the arterial transplantation if the caliber of the vessels were similar.

A segment of vein transplanted into an artery undergoes immediately very marked change. Its lumen is dilated, but its wall becomes thicker and stronger. No aneurism has ever been observed. It seems, on the contrary, that the vein adapts itself to its arterial functions, and reacts against the increased blood pressure by thickening its wall. The anatomic changes begin very soon after the operation. Fourteen days after the operation Guthrie and myself found the wall of the transplanted segment very much thickened. The thickening was produced mainly by an increase of the connective tissue of the adventitia and the interstitial tissue of the muscular coat. This very considerable thickening does not always happen. In a specimen that I extirpated fifteen days after the operation the wall was only slightly thickened. There was a little dilatation of the lumen. The anastomoses and the intima were smooth and glistening (Fig. 5). The periadventitial tissue mainly was thickened.

Twenty-six days after the operation Watts found the intima uniformly thickened and lined by flat endothelial cells. The thickening of the media was due mainly to the increase of the interstitial connective tissue. There was also a marked increase of the adventitial and periadventitial connective tissue. Stich and Makkas observed that sixty-five days after the transplantation the wall of the venous segment was two or three times as thick as normal.

Four months after the operation I resected from a segment of jugular transplanted into the carotid artery

a little piece of the wall and again sutured the vessel. The histologic examination showed an enormous increase of the adventitial connective tissue and a very large increase of the interstitial connective tissue of the media. The muscular fibers were normal.

The remote results are excellent. Eight months after the operation, I extirpated the carotid artery of a dog into which a segment of jugular had been transplanted. The lumen of the vein was dilated, but its wall was very thick and strong. There was no stenosis or dilatation of the anastomoses. The intima of the vein had in the neighborhood of the anastomoses a scar-like appearance (Fig. 6).

The circulation remains generally excellent, but exceptionally obliteration occurs a long time after the operation. A cat had undergone successfully the transplantation of a segment of vena cava into its aorta. The pulse of the femoral arteries remained normal. About eight months after the operation the cat began to be slightly ill. Nine months after the operation the pulse of the femoral arteries disappeared, and about fifteen days afterward the cat was chloroformed. A voluminous abscess of the kidney was found to be the cause of illness. The transplanted segment was externally normal, but obliterated by a parietal clot of recent formation. The anastomoses were smooth and almost invisible. It was probably a case of infectious phlebitis developed on the transplanted segment.

These experiments show that a vein can adapt itself to the arterial functions. But it seems that the transplantation of veins on arteries is less safe than the transplantation of arteries on arteries.

Transplantation of Preserved Arteries.—Therefore, it would be very important to find a method of preserving tissues outside of the body for a few days or a few weeks. From an amputated limb or from the fresh cadaver of a man killed by accident the arteries would

be extirpated and kept until needed for transplantation on another man. In order that the grafted vessel can resuscitate itself, it is necessary that irreversible changes do not take place in the tissues during the period of preservation outside of the body. The cadaveric disintegration of tissues is caused by microbian and autolytic fermentations. The microbian element can be eliminated without great difficulty by keeping the tissues in aseptic condition. It is more difficult to prevent the chemical modifications due to autolysis. Nevertheless, the action of the autolytic enzymes can be inhibited by several physical or chemical means. For instance, chloroform in absence of oxygen retards autolysis. It is well known also that autolysis is partially inhibited by normal blood serum. Opie has isolated from the serum an antibody for the proteolytic ferments of the leucocytes. The temperature also has a marked action on the enzymes. At a few degrees above the freezing point their action becomes very slow. I attempted to use the influence of the cold on the enzymes for preserving the vessels. Therefore, segments of arteries were aseptically extirpated and preserved in cold storage slightly above the freezing point. Concerning the nature of the preservative fluid and the optimum temperature, no definite technic has yet been adopted.

The actual method consists of extirpating the vessels under rigid asepsis, of washing them in Locke's solution and of immediately placing them in a glass tube, which contains, on a small piece of absorbent cotton, a few drops of Locke's solution. The tube is sealed and put into an ice box, the temperature of which is constantly between 0 and 1 C. Some vessels have been preserved also in tubes filled with Locke's solution. The vessels undergo very little gross anatomic changes during the first weeks. Afterward they become less elastic. The periadventitial connective tissue acquires a soapy consistency. However, from a histologic standpoint, the

muscle fibers remain ordinarily normal, even after one month.

In some cases where infection occurred the nuclei of many muscle fibers did not take the stain and the wall was partially necrosed. If that method is to be used in clinical surgery, it would be necessary to examine a frozen section of the preserved artery just before transplantation. A few segments of vessels have been preserved for several months. The carotid of a dog kept in cold storage since Feb. 4, 1908, has still an almost normal appearance after four months.

Arterial segments were transplanted after having been kept in the refrigerator from one to thirty-five days. The occurrence of thrombosis was observed mainly at the beginning of the use of the method. Clinical and histological examinations of the results were made from five days to one year and a half after the operation. The gross anatomic changes of the vessels are ordinarily very slight. But the wall presents generally marked histologic lesions.

These lesions seem to depend on the nature of the preservative used and the length of time spent in the refrigerator. A fragment of carotid artery transplanted into a dog after twenty-four hours of cold storage in salt solution, showed a complete destruction of the muscle elements five days after the operation. In another case very little change of the muscle fibers was observed after eighteen days.

The following observation shows a segment of artery preserved in cold storage for ten days acts as a living vessel probably for an indefinite period of time. On Feb. 26, 1902, a segment of carotid was extirpated from the body of a dog thirty-five minutes after death and preserved in a tube of Locke's solution in cold storage. On March 6 this segment was transplanted into the left carotid artery of a dog. On May 3, 1901, we examined, with Dr. Crile, the neck of this dog, and found that the transplanted segment had the same ap-

pearance as the other parts of the artery.. On May 15, 1908, the neck of the dog was opened again. The left carotid artery appeared to be entirely normal. By a careful dissection one of the anastomoses was exposed. There was no induration of the wall at its level. The only evidence of the suture was a very narrow dark line on the adventitia. The parts of the vessel located above and below the anastomoses were absolutely identical in color, caliber and consistency. It was impossible to know if the transplanted segment was below or above the exposed anastomosis. The carotid was then completely dissected and the second anastomosis easily located. The transplanted segment was altogether similar to the other parts of the carotid.

The carotid artery and the transplanted segment were extirpated. When the carotid was empty and retracted itself, the transplanted segment became very apparent, because it did not contract itself. It had evidently lost all its elasticity. The intima was smooth and glistening. The location of the anastomoses was marked merely by a slight difference in color (Fig. 7). There was no evidence of scar, from a gross anatomic standpoint. Sections were examined with hematoxylin-eosin, Weigert and van Geison stains. The three arterial coats were easily seen, but their constitutions were modified. The intima was thickened, and, in a point where the media was a little thinner, presented a patch of greater thickness. The cellular tissue of the adventitia was also increased. The media was very much modified. Its internal portion had undergone hyaline degeneration. The external part was composed of fibers, of which it was difficult to say if they were connective or muscular. The elastic framework had entirely disappeared. It must be noticed that in spite of the lack of elastic tissue, the vessel has not undergone any dilatation and was apparently normal. Before the transplantation the vessel presented marked histologic lesions of its wall, due to several microbian colonies which had settled into

the media during the period of preservation. A few other animals into which segments of vessels preserved in cold storage were grafted demonstrate that the remote results of this operation may be excellent.

A segment of popliteal artery was taken from the leg of a young man. This vessel was extirpated from the leg twenty-four hours after the operation and kept for twenty-four days in cold storage. Then it was transplanted into the abdominal aorta of a small bitch. A second laparotomy was performed five months after the operation. The aortic circulation was normal. The transplanted segment was about in the same condition as at the time of the transplantation, although its wall was a little thicker and harder. To-day, one year and two months after the operation, the animal is in perfect health and the pulse of the femoral arteries is normal.

After the transplantation of a segment of carotid of dog kept for thirty-five days in cold storage into the aorta of a cat, the aortic circulation remained normal. Into the aorta of another cat a segment of carotid of dog kept in cold storage for twenty days was transplanted in November, 1906. The animal is still living, and its femoral pulse is normal.

These observations show that a vessel transplanted after having been kept in cold storage for a few days or weeks can functionate normally for a long time. The anatomic results are excellent, for the vessel, in spite of deep histologic changes, is not a dead but a living structure.

Other methods of preservation of vessels have been tried, but with little success. I transplanted segments of arteries which had been frozen for several days. The immediate results were sometimes apparently excellent. But, ultimately, in all cases except one, obliteration, atrophy and absorption of the vessel occurred after a few days, weeks or months.

The transplantation of devitalized arteries has been attempted by Levin and Larkin in New York. Their

purpose was to ascertain whether a new vessel can develop around the segment of dead artery sutured between the cut ends of another artery. They used boiled arteries, and arteries fixed in formalin. Immediately after the transplantation the boiled or formalinized vessel presents almost the same appearance as a normal vessel. In almost every case thrombosis occurred. However, after the transplantation of a segment of aorta fixed in formalin into the aorta of a dog, excellent circulation was observed. Histologic examination ten days after the transplantation showed that the wall was composed of amorphous tissue in which the elastic framework was seen to be very well preserved. In another case of Levin and Larkin, twenty days after the operation, the wall of the vessel was completely amorphous and surrounded by dense connective tissue. A similar experiment has been performed in St. Louis by Guthrie, who obtained an excellent functional result, but no histologic examination of the vessel has yet been published. Ward in New York has also transplanted arteries fixed in formalin, but thrombosis occurred. Levin and Larkin have attempted to substitute for an artery a segment of ureter sterilized by boiling. Thrombosis occurred.

I found that it is possible to use peritoneum as a substitute for the arterial wall. I performed this operation twice only, and in each case the result was excellent. A dog onto whose aorta I grafted a piece of peritoneum more than one year ago is still alive and its femoral pulse is normal.

Transplantation of Arteries Between Animals of Different Species.—It is generally believed that a piece of tissue transplanted from one animal into another of different species undergoes cytolysis and disappears. It is not always true. There are several varieties of heteroplastic transplantations according to the zoologic distance which separates the host and the owner of the transplanted tissue. If a piece of tissue is transplanted

from an animal to another and very different animal—from the mouse to the lizard, for instance—cytolysis occurs. But if the owner of the tissue and the host belong to more closely related zoologic sections, as, for instance, the guinea-pig and the rabbit, the graft does not undergo any cytolysis, but gradually disappears by atrophy. A few vessels are formed, but the vascularization is much less developed than it happens when the animals are of a same species. It seems that the grafted tissue is resorbed by inability to receive for itself sufficient nourishment. Nevertheless, as it has been shown by Cristiani, grafts between animals of different species, as guinea-pig and rabbit, can take. But these grafts are less vascularized than normally. These facts led me to attempt heteroplastic transplantation of blood vessels, with the view that between animals as closely related as cat and dog, or man and monkey, the vessel would not undergo any cytolysis, but would stand the serum of the other animal, and, perhaps, adapt itself to its new conditions of life.

Heteroplastic transplantations of vessels have been performed by Hoepfner in Berlin several years before my experiments. But the results were absolutely negative. Nevertheless, in December, 1906, I presented before the American Physiological Society a cat into which a segment of carotid artery of a dog had been grafted. The femoral pulse was normal. An exploratory laparotomy was performed afterward and the transplanted segment found almost normal. To-day, one year and seven months after the operation, the femoral pulse is still normal. At the same time, Stich and Makkas transplanted successfully segments of arteries from rabbit and cat to dog, and from man to dog. Afterward Guthrie successfully grafted onto a dog the arteries of a rabbit and cat. In 1908 Wood made the histologic study of the heteroplastic transplantation of Ward and obtained important indication about the modifications undergone by the vessels in their new condition of life.

From a clinical standpoint, the operation is more often successful when the animals are closely related. Between dog and cat, or cat and dog, the results are very often positive. I obtained almost always positive results by transplanting segments of carotid of dogs into the abdominal aorta of a cat. But my transplantations from cat to dog have been generally negative, and even in one case the transplanted vessel produced a fusiform aneurism. Stich and Makkas, Wood and Ward, and Guthrie obtained positive results with arteries transplanted from cat and rabbit to dog. The first successful transplantation of a human vessel into a dog was published by Stich and Makkas. I made several experiments of this kind. Two cases only were positive. But in every case the vessel had been kept in cold storage for several days prior to the transplantation. In the successful experiments the remote results were excellent. A bitch into the abdominal aorta of which a piece of human popliteal artery was grafted one year and one month ago is still in good health and its femoral pulse is normal.

It is important to study accurately the anatomic changes undergone by the vessels. Their anatomic evolution will be divided artificially into three periods: before the twentieth day, from the twentieth day to the seventieth day, and after the seventieth day. During the first two weeks the transplanted segment remained normal from a gross anatomic standpoint. My sections showed very little histologic changes. The muscular fibers are normal. The interstitial connective tissue is slightly increased. Generally, the intima is free from a thrombus. In a case of transplantation of human vessel on dog, I found the intima completely covered by a thin layer of fibrin. Stich has observed the same disposition. This layer does not interfere with the circulation, but isolates the transplanted vessel from the blood. Wood has found that twenty days after the operation the

lesions of the elastic fibers are already marked, while the muscle fibers are still normal.

The lesions are more marked on rabbits' than on cats' vessels, when transplanted on dogs. From the twentieth to the seventieth days, the vessel undergoes a more or less marked dilatation of its lumen. The lesions are characterized by a progressive and complete disappearance of the elastic framework, by a diminution in the number of the muscle fibers, an increase of the interstitial connective tissue, and a thickening of the intima. Nevertheless, the endothelium may persist. Fifty-two days after the operation Stich saw the endothelium covering the anastomosis.

In another case, where the wall was covered partially by a parietal thrombus, the intima was lined by endothelial cells. Wood found that seventy days after the operation all the elastic tissue had disappeared. Afterward the lesions seem to go on slowly. After six months I found the carotid artery of a dog, transplanted on a cat, very much dilated. The intima was smooth, and there was no evidence of the anastomoses (Fig. 8). They could be approximately located only by the beginning of the dilatation. No elastic fibers could be detected. The media was deeply modified. Its internal part had in part undergone hyaline degeneration. The external part was composed of connective tissue and a few fibers, presenting the histologic reaction of muscle fibers. The adventitia was thickened.

This shows that the vessel does not undergo any cytolysis. Slowly the elastic fibers disappear, the lumen becomes dilated, the connective tissue increases, and the muscle fibers, which at first remain normal, diminish in number, and finally are almost completely resorbed. The vessel is progressively transformed into a tube formed almost exclusively of connective tissue. But this tube is made of living tissue and can act as an artery for one year and a half, at least.

II. THE TRANSPLANTATION OF ORGANS.

The transplantation of an organ consists in its removal and graft into another animal and the re-establishment of its circulation by vascular anastomosis. This method alone permits the transplantation of a whole organ, like the kidney or the spleen. As regards glands like the thyroid, parathyroid and ovaries, the action of which on the organism is efficient even when the volume of glandular tissue is small, it is not necessary to perform the anastomosis of the vessels. The old method of grafting small pieces of tissues by simple implantation is often sufficient, as it has been abundantly proved, for the ovary by Knauer and Foa, and for the thyroid gland by Cristiani. But even in this case it would be of value in transplanting the complete gland and of re-establishing immediately a normal circulation through its vessels.

Transplantation of the Thyroid, Parathyroid, Suprarenal Glands and the Ovaries.—In 1902 I performed with Morel the extirpation and the re-plantation of the right thyroid gland of a dog. The vessels were anastomosed, but coagulation soon occurred. In 1905 I succeeded with Guthrie in extirpating and replanting the thyroid gland with reversal of the circulation. Eleven days after the operation the wound was opened and the circulation of the gland was found going on. The animal is still alive and the anatomic examination of the gland will be made later. In 1907 Stich and Makkas performed a series of transplantations of dog's thyroids. On Oct. 25, 1907, Stich extirpated both thyroids from a dog and replaced one of them. The animal remained in good health. On Jan. 25, 1907, the replanted gland was extirpated and found normal from a histologic standpoint. The animal became ill after this operation, but finally recovered. Other experiments were performed, and lately Garre announced that in ten operations he obtained three positive results. It is well known

that the transplantation of small pieces of thyroid gland under the skin, into the spleen, or the bone marrow, may give excellent results. The experiments and the operations of Cristiani, Kocher, Garre, Payr and others show that a fragment of gland transplanted in these conditions can functionate normally. But, perhaps, as Garre thinks, it would be better to transplant a larger amount of gland, and consequently to use the transplantation with anastomoses of the blood vessels.

The brilliant results obtained by Halsted in the transplantation of the parathyroid, and by Bush and Schmieden in the transplantation of the suprarenals, show that the graft of these small bodies by simple implantation is efficient. Nevertheless, it would be possible also to graft the parathyroids with immediate re-establishment of the circulation, by using the method of transplantation in mass.

I attempted to develop a method of transplantation in mass of the suprarenal glands on cats. A first cat was killed and both suprarenals extirpated with the corresponding segments of the aorta and vena cava. On a second cat the aorta and vena cava were transversely severed a few centimeters below the kidneys, the anatomic specimen was placed into the abdominal cavity, and the ends of the aortic and caval segment united to the ends of the aorta and vena cava. The circulation was immediately re-established into the suprarenals. Four experiments were performed. On two animals the glands were found degenerated or atrophied. Two others are still living, more than six months after the operation, and will be examined later. It is probable that the glands are resorbed.

The ovaries can be transplanted from one animal to another by a similar method. I made, with Guthrie, a few operations of this character in Chicago. But the transplantation of the ovaries is so successful by simple implantation that a complicated vascular operation

seems to be unnecessary. This question was almost completely settled several years ago, chiefly by the experiments of Knauer and also Foa. In 1896 Knauer published the results of his ovarian transplantations. The ovary was implanted into the peritoneal cavity. Three years after the operation he found the grafted organ normal from a histologic standpoint. In two cases the animals became pregnant. In four cases of Grigorieff pregnancy was also observed. In 1900 Foa made an extensive series of experiments on rabbits and studied the transplantation of embryonal or adult ovaries. He examined the evolution of embryonal ovaries grafted on adult or old rabbits, and discussed the biologic problems which can be solved by this method.

In 1907 Guthrie again took up this question with a method similar to that of Knauer and Foa. But, instead of using rabbits, he operated on chickens. This is a marked improvement, for chickens are very much easier to operate on than mammals. His results were excellent, and he could obtain offsprings from the grafted animals. The clinical applications of Knauer, experiments by Morris and many others are too well known to be discussed again.

Extirpation and Replantation of the Spleen.—The spleen of dogs is very favorably disposed from an anatomic standpoint for transplantation. The operation is very simple. On a medium-sized dog the abdomen is opened through a transverse incision and the spleen is eviscerated. Then the gastro-splenic vessels are isolated, ligated and severed. All the other vessels are ligated and cut. The splenic vessels are dissected, the nerves cut, and the temporary hemostasis is secured by two *serre-fines*. The vessels are cut and the organ extirpated. It shrinks very much immediately. A canula is introduced into the splenic artery and the organ is washed out as thoroughly as possible with Locke's solution. Then it is immersed in a jar full of

Locke's solution. The central ends of the splenic vessels are washed and prepared for the anastomoses. Afterward the spleen is removed from the jar, placed into the abdominal cavity and the peripheral end of the splenic vessels are united to the central end. The circulation is re-established. The organ becomes red and its size increases very much on account of the paralytic vaso-dilatation. The nerves are sutured. Then the organ is suspended to the great curvature of the stomach by suture of the gastro-splenic pedicles. The omentum is properly fixed and the abdominal wound is closed.

The operation is easy when the animal is of large size. Several months ago I performed this operation twice only, on a medium-sized dog and also on a large dog. Both animals recovered uneventfully and are in good health. The anatomic results will be published in one or two years.

Transplantation of the Intestines.—This operation consists of extirpating a loop of intestine from an animal and of substituting it for a loop of intestine of another animal. The ends of the extirpated loop are sutured in order to prevent contamination of the operative field, and the vessels are carefully perfused with Locke's solution. Then the intestine of the second animal is resected and the mesenteric vessels are prepared for anastomosis. The loop is interposed between the cut ends of the intestine. The vessels are anastomosed and the circulation is re-established. The intestine almost immediately takes on its normal color, and strong peristaltic movements appear. Then the continuity of the gut is re-established by two intestinal anastomoses.

I performed this operation only twice. In each case infection occurred. The postmortem examination showed gaseous cysts under the peritoneal coat of the transplanted loop of intestine. It is probable that during the period of anemia the microbes of the intestine penetrate the wall. In this case a successful trans-

plantation of the intestine will be probably unrealizable, or, at least, exceedingly difficult.

Transplantation of the Kidneys.—In 1902 the first attempt of transplanting a kidney was made by Ullmann. He removed a dog's kidney and transplanted it into the neck, the vessels being united by means of Payr's prothesis. The same year I performed several transplantations of the kidneys on dogs. Septic complications occurred in every case. Decastelle the same year reported similar experiments. In 1903 Carl Beck, of Chicago, performed a transplantation of the kidney by using Murphy's method of anastomosing blood vessels. In 1905 Floresco published a few cases of the transplantation of the kidney in the lumbar region. These experiments gave few facts about the functions of the transplanted organ. In one case, however, a sample of fluid, flowing from the ureter five days after the operation, was examined and presented the characters of urea. Guthrie and I examined for the first time the functions of a transplanted kidney and found that they are not very different from the normal. We also performed the transplantation in mass of the kidneys of a dog from whom both kidneys were removed and replaced by the kidneys from another dog and found that the secretion went on. Afterward Stich and Makkas published the results of a transplantation of a kidney in the lower abdominal region. The normal kidneys were not removed and consequently the usefulness of the transplanted organ could not be determined. During the last two years at the Rockefeller Institute I performed a series of transplantations in mass on cats and another series of simple transplantations and replantations on dogs. These experiments demonstrated that replanted and transplanted kidneys can functionate normally.

The transplantation in mass of the kidneys consists of extirpating from a first animal both kidneys, their vessels and the corresponding segments of the aorta and

vena cava, their nerves and nervous ganglia, their ureters and the corresponding part of the bladder (Fig. 9); of placing this anatomic specimen into the abdominal cavity of a second animal whose normal kidneys have been previously resected and the aorta and vena cava cut transversely (Fig. 10); and of suturing the vascular segments between the ends of the aorta and vena cava, and of grafting the flap of bladder onto the bladder of the host (Fig. 11). In every case the re-establishment of the renal functions was observed. These functions were determined by the character of the urines and the general condition of the animals.

The secretion of urine may begin as soon as the arterial circulation is re-established. In several cases clear urine flowed from the ureters while the flap of bladder was being grafted onto the host. More often no urine was seen flowing from the ureters immediately after completion of the operation. But the secretion always began during the first twenty-four hours. In some cases the amount of urine during the first twenty-four hours was more than 100 c.c. However, a cat urinated only 25 c.c. during the first twenty-four hours; the second day the amount of urine passed was only 16 c.c.; this urine was highly concentrated and contained much urea. In all the experiments the urinary secretion went on as long as the animal lived. Every cat urinated abundantly every day, but the animals presented sooner or later some complication, which modified in some measure the renal functions.

As is to be expected after an operation as complex as the transplantation in mass, various accidents occurred; hydronephrosis, intestinal compression by peritoneal adhesions, volvulus, phlegmon, puerperal infection, compression of the renal veins by organized hematoma of the connective tissue, which were the direct or indirect causes of death in these animals. It is well known that several of the complications, especially the compression

of the renal veins, produce grave renal lesions of their own. Therefore, the results of our experiments must not be considered as expressing generally the normal condition of transplanted kidneys, but merely of transplanted kidneys when subjected to various complications, that is, of more or less abnormal transplanted kidneys. However, in two experiments the functions of the kidneys seem to have been for a certain time almost completely normal.

The color of the urine was yellow, generally, or often less dark than the normal urine of the cat. Its reaction was acid. Its quantity for twenty-four hours oscillated between 120 and 160 c.c., but it might be, exceptionally, 25 and even 15 c.c., or in another case, 215 or 255 c.c. for twenty-four hours. In this case there was congestion of the kidneys produced by venous compression. The density was very far from constant; generally it oscillated between 1.018 and 1.030, going sometimes as high as 1.035 and 1.051. Once the kidneys secreted 170 c.c. of urine with a density of 1.035.

Among the abnormal constituents of the urine the presence of albumin only has been looked for. In some cases there was a little albumin during the first days, ranging from 0.50 to 0.25 for 1,000 c.c. In other cases the albumin disappeared about one week after the operation.

The general condition of the animal can be used, in some measure, to indicate the perfection of the urinary elimination. As long as no complications were present the animals lived as normal cats do, without presenting any symptoms which could be considered as produced by renal insufficiency. When general complications occurred the cats reacted against them in normal ways. In one case, the animal was in apparently normal condition four days after the operation. She walked about the room, played, and ate a great deal of raw meat. Her condition remained excellent for several weeks. Twenty days after the operation she was in good health,

had glossy hair, was very fat, ate with appetite all kinds of food, and urinated normally (Fig. 12). There was, however, albumin in the urine, and slow and progressive enlargement of the kidneys took place, which showed that she was not in an entirely normal condition. One cat was in excellent health until the twenty-ninth day after the operation. Then gastrointestinal symptoms appeared, and death occurred on the thirty-first day after the operation.

In another experiment the animal was a female cat which lived in the laboratory for several months. She was in excellent condition when she was operated on and recovered very quickly from the operation. Her life went on just the same as before. The kidneys were movable and small. She looked in excellent health and lived as a normal cat. On the eighteenth day after the transplantation albumin appeared in the urine and a direct examination of the kidneys was made to ascertain the cause. The general condition was little affected by the operation and the albumin disappeared on the twenty-first day, but reappeared again a little later. On the thirty-fifth day the animal was very weak and emaciated. She died on the thirty-sixth day of acute calcification of the arteries.

We can conclude from these results that the functions of the kidneys re-established themselves after the transplantation. Since an animal can live in an apparently prosperous condition of health fifteen or twenty-five days, and more, after a double nephrectomy, and eliminate each twenty-four hours 120 and 160 c.c. of urine through the new kidneys, it is certain that the functions of the transplanted organs are efficient.

The histologic examination of the transplanted kidneys showed that the organs presented some lesions, very slight in some cases, and more marked in others. The lesions belonged to two classes: hydronephrosis and subacute interstitial nephritis. Nephritis is not a neces-

sary complication of the transplantation, for it was completely absent in some cases. It is possibly due to secondary causes. In the cat which died of general calcification of the arteries thirty-six days after the operation, the secretory tubules were remarkably well preserved, and there was no increase of connective tissue around them. The morphologic changes undergone by these kidneys were very small. The organs were almost normal.

Simple Transplantation and Replantation of the Kidneys.—The transplantation in mass of the kidneys permits of an almost ideal reconstruction of the urinary apparatus after a double nephrectomy. However, it is a complex operation, and the animal is exposed to many complications. The method called "simple transplantation" exposes the kidney to ureteral or vascular troubles, but it is practically harmless for the animal itself. This operation consists simply of dissecting a kidney, cutting the renal vessels and ureter a few centimeters below the hilus, implanting the organ on the same, or another animal, and of anastomosing its vessels to the renal vessels of the host.

I performed the double nephrectomy and the replantation of one kidney in five dogs. The secretion of the urine remained normal as long as no ureteral complication occurred. The conditions of the kidneys were excellent. A little more than two months after the operation, the location of the anastomoses of the renal vein could not be detected. The anastomosis of the renal artery was seen as a small and indistinct line on the intima (Fig. 13).

The remote results of this operation are excellent. On February 6 the left kidney of a middle-sized bitch was extirpated, perfused with Locke's solution and put into a jar of Locke's solution at the temperature of the laboratory. The ends of the vessel were prepared for anastomoses, and afterward the kidney was replaced into the abdominal cavity. The circulation was re-

estalished after suture of the vessels and the ends of the ureter united. The animal made an uneventful recovery. Fifteen days afterward the right kidney was extirpated. The animal remained in perfect health. The urine did not contain any albumin. It is generally of low density. To-day the animal is in perfect condition (Fig. 14).

This observation demonstrates definitely that an animal can live in normal condition after both kidneys have been extirpated and one replaced. It removes also, without need of further discussion, the objections of the experimenters who claim that the section of the renal nerves, the temporary suppression of the renal circulation, or the perfusion of the kidneys produce necessarily dangerous and even fatal lesions of this organ.

The transplantation of a kidney from a dog to another dog has been performed by the same method. Two large dogs underwent a unilateral nephrectomy one year ago, and the extirpated kidney was replaced by the kidney from another dog. The two animals recovered in a few days, and are still in excellent health; but, as a normal kidney has been left, no conclusion can be drawn at the present time regarding the functions of the transplanted organ.

III. TRANSPLANTATION IN MASS OF THE AURICLE, THE EXTERNAL AUDITORY CANAL, PART OF THE SCALP, LYMPH GLANDS OF THE NECK AND PARTS OF THE COMMON CAROTID ARTERY AND EXTERNAL JUGULAR VEIN FROM A DOG TO ANOTHER DOG.

By using the method of transplantation in mass it becomes possible to perform the transplantation of a whole anatomic region, with its main artery and vein. The limits of the anatomic specimen must be approximately those of the field of distribution of the main artery. But, on account of the collateral circulation, it would be impossible to transplant a very much larger

region. For instance, the whole scalp can probably be transplanted successfully if the vascular connections are re-established on one side only.

The following observation is an illustration of the transplantation from a dog to another of the anatomic structures supplied by the external carotid artery. From a first dog, the right part of the scalp and the auricle were extirpated in one mass with the cartilaginous portion of the auditory canal cut close to the skull, the connective tissue and the glands of the retro-maxillaris space, the tissues of the carotid region, and the upper portions of the external jugular vein and of the common carotid artery. A canula was introduced into the end of the artery, and the anatomic specimen perfused with Locke's solution. Then it was wrapped in a greased silk towel and placed on a table at the temperature of the laboratory. On a second dog the auricle and a portion of the scalp was extirpated and the right part of the neck opened through a longitudinal incision. The anatomic specimen was then placed close to the wound, and the peripheral end of the carotid artery and of the jugular vein united to the central end of the corresponding vessels of the host, at the level of the middle part of the neck. The circulation then was re-established. An abundant hemorrhage occurred from the peripheral branches of the carotid artery, which were immediately ligated. Then the neck was closed by two rows of suture. The purpose of making the vascular anastomoses very far from the transplanted ear was to prevent the occurrence of thrombosis in a case where infection would be produced in the upper part of the wound by insufficient asepsis of the transplanted skin flap.

A few minutes after the establishment of the circulation the ear and the scalp assumed their normal appearance. The new ear was fixed by circular suture of its cartilaginous canal to the cartilaginous canal of the host. The auricular muscles were sutured and the

operation completed by continuous catgut suture of the skin without drainage.

During the days following the operation edema of the auricle occurred, but the circulation remained excellent and the temperature of the transplanted ear was much higher than that of the normal ear. The cutaneous wounds united by first intention, but a voluminous abscess appeared under the scalp and had to be drained eight days after the operation. The local conditions improved quickly, the edema of the auricle diminished and disappeared, but the animal had some chills, and a secondary abscess appeared in the left leg. The animal developed a slow form of pyemia.

The local condition became excellent. The auricle and the transplanted tissues were in normal condition. The temperature of both auricles, normal and transplanted, were about the same. The transplanted ear was as thin and glossy as the normal one. Except for the difference of color, it could not have been seen that the ear did not belong to the dog (Fig. 15). He finally died three weeks after the operation of pyemia. The transplanted parts were normal. This is the only attempt I did of transplanting an anatomic region, but this method can have many other applications.

IV. THE TRANSPLANTATION OF LIMBS.

The transplantation of a limb from one animal to another of the same species is a problem very much simpler than the transplantation of a gland. It presents some difficulties, merely from a surgical standpoint. The anatomic structures of a limb are resistant and do not undergo autolytic modification after a short time of anemia. Besides, it is well known, from a clinical standpoint, that the circulation of a limb can be stopped completely for several hours by an Esmarch bandage without further occurrence of any lesions or nervous troubles. It is permitted also to suppose that structures, such as

skin, muscles, vessels, bones, etc., are not very sensitive to slight modifications in the composition of the serum, and that after transplantation the blood of their new owner would not be toxic for them. Besides, it is almost certain that the new limb would have no harmful influence on his host, as may happen after a transplantation of the kidneys. Therefore, there is apparently no reason why the leg or the arm of an animal or of a human being could not be transplanted successfully on another animal of the same species or another human being.

In April, 1907, I found that a thigh, extirpated from the fresh cadaver of a dog, and transplanted onto another dog, could begin to heal in a very satisfactory manner. A black, medium-sized male dog was killed by chloroform. Thirty minutes afterward the left thigh was amputated just below its middle part, perfused with Locke's solution and kept on a table at the temperature of the laboratory. Then a white bitch of the same size was etherized, her left thigh amputated and immediately replaced by the thigh of the black dog. The femur, the adductors and quadriceps muscles were immediately sutured. Then the femoral vessels were united and the circulation re-established through the limb, three hours and ten minutes after its death. The femoral and sciatic nerves, the muscles, aponeurosis and skin were sutured and a plaster-of-Paris dressing applied.

During three days the animal remained in excellent condition, eating, drinking, and walking on his three normal feet. The transplanted limb was warmer than the normal one, and its circulation very active. On the fourth day the animal was ill. The dressing was removed. There was a phlegmon of the thigh. Then incisions were made on the new and normal parts of the thigh. Abundant hemorrhage of red blood occurred from the incisions of the transplanted leg. Drainage was established. Nevertheless, on succeedings days, the foot became swollen and the general condition of the

animal declined. However, the circulation of the transplanted limb remained active. Nine days after the operation a very large abscess was detected in the upper part of the thigh near the pelvis. The animal died of infection ten days after the operation. Anatomic examination of the body showed that the cutaneous incisions healed by first intention and that a large abscess had developed around the bone and infiltrated the intermuscular spaces of the upper part of the thigh. The muscles were normally united.| The anastomoses of the femoral artery and vein were perfectly cicatrized and the vessels entirely normal.

This case demonstrated that it is possible to reestablish the circulation into a transplanted thigh and to obtain cicatrization of the anatomic structures. The union of the vascular anastomoses was excellent and the circulation of the limb constantly normal. Therefore, it was probable that, by using a little better technic, definitive results could be obtained.

A few other operations were performed, but in every case breaking of the bone suture or infection occurred. Nevertheless, by using more careful asepsis in the transplantation of the leg from one fox terrier to another, I observed union by first intention of the new leg to its host.

A white, middle-aged male fox terrier was etherized and the skin of the left leg cut circularly just below the knee. The thigh was opened by a longitudinal internal incision, the femoral and saphenous vessels dissected from Poupart's ligament to the circular incision, and cut in the upper part of the thigh. Then the leg was amputated below the knee and the dog chloroformed. The limb was perfused with Locke's solution, wrapped in a greased silk towel and kept on a table at the temperature of the laboratory. A white, young female fox terrier was etherized. She was of the same size and shape as the first dog. Her nails and bones were very slightly smaller. The leg was amputated circularly

just below the knee. The new leg was immediately fixed to the central end of the tibia of the host by an Elsberg's aluminum splint. Both fibulæ were ligated. The internal part of the muscles, the anterior and posterior tibial nerves were united. Then a longitudinal incision was made along the internal part of the thigh, the femoral vessels exposed, dissected and united to the femoral vessels of the host and the circulation re-established. The muscles, aponeuroses, and skin were sutured with catgut, and a plaster-of-Paris dressing applied. A small exploratory incision was made between the second and third toes. Hemorrhage of red blood occurred. The animal recovered quickly and remained in normal condition. The temperature of the new foot was at first higher than that of the normal one. It was also edematous. After a few days the edema disappeared and the foot had exactly the same appearance as the normal one. The temperature went slightly down. There was only a difference of one-tenth of a degree centigrade between the normal and the new foot.

Fifteen days after the operation the new leg was perfectly healed. The cutaneous wound had healed by first intention, but the bones were not very strongly united. The Elsberg splint had broken and the tibia was a little incurved. The exploratory incision of the foot, although having been a little infected, was completely cicatrized. The new leg had the same appearance as the normal one.

A slight edema still existed above the ankle joint. The animal was in good condition, but coughed a little. At this time several other dogs died of bronchopneumonia. The animal became sick. Twenty days after the operation her condition became worse, and a marked dyspnea appeared. The dog died on the twenty-second day after the operation. Postmortem examination showed a double diffuse bronchopneumonia. The new leg was perfectly healed; with linear cutaneous scars. Its appearance was exactly the same as the normal leg (Fig. 16). The bones were strongly united by a fibrous

callus (Fig. 17). The exploratory incision of the foot had healed without visible scar.

This experiment is the first example of successful grafting of a new limb on an animal. It demonstrates that the leg, in spite of the change of owner, remains normal. After a short period of edema and of high temperature, due perhaps to secondary causes, the new leg assumed the same appearance as the normal one. The temperature of the new foot did not differ from that of the other posterior foot. The healing of the cutaneous incision occurred normally, and the appearance of the skin was the same above and below the circular incision, that is, on the normal and transplanted part of the limb. No trophic troubles occurred. The cicatrization of a small exploratory incision made on the transplanted foot became slightly infected. Nevertheless, it healed rapidly, and the cicatrization was so perfect that the scar was not discernible on the twenty-second day.

It was also very important to ascertain whether or not the bone would heal normally. Some experimenters claim that the separation of bone is very much disturbed when the nerves of the limbs are cut. This is probably due to some secondary causes. But, in the transplanted leg the union of the normal and new tibias occurred in a normal way. The ends of the bones were strongly united by a fibrous callus, as can be expected in a case of ordinary fracture about twenty days after the operation. There was, of course, no re-establishment of mobility or sensitiveness in the new limb. It was too soon after the operation. The mobility and sensitiveness of the leg can not reappear probably before several months.

As a conclusion, we know that all the anatomic structures of a transplanted leg heal normally. The question of the regeneration of nerves, and of the re-establishment of the functions, has still to be studied. Although these results are new, they were easy to foresee, for they

have been prepared, in some measure, by the work of other experimenters along a little different line. In 1891 Robert Abbe amputated almost completely the front limb of a dog. He cut all the structures, except the femoral vessels. Then he sutured the bone, the nerves, the muscles, and the skin, and the animal recovered completely. If he had had at his disposal an efficient method of anastomosing blood-vessels, he would have doubtless realized a real replantation of the limb. Hoepfner, in 1903, amputated the thigh of a dog and replanted it immediately by suturing the bone and all the anatomic structures of the limb, and united the vessels by Payr's protheses. In one case the circulation remained excellent. Unfortunately, the animal died eleven days after the operation. The tissues of the limb were well united, but the bone had very little tendency to callus formation.

In 1905, in Chicago, I performed, with Guthrie, several experiments of replantation of the thigh. We obtained also excellent healing of the vessels and tissues, but no animal could be observed more than eleven days. At the Rockefeller Institute I did not perform any other experiments of this character, for the practical application of the replantation of limbs will always be extremely limited. It was more useful to study the transplantation from one animal to another, on account of the possible practical applications of this operation in human surgery. If further experiments show that the functions of the transplanted limb are normally re-established, it will be permitted to try on man the transplantation of limbs, or segments of limbs, taken from an amputated limb, or from the body of a man killed by accident.

CONCLUSIONS.

Regarding the practical applications of the transplantation of blood vessels and organs, as well as the transplantation of limbs, it is necessary to emphasize

that even a method which gives excellent results on animals must not be applied directly on man. There are marked anatomic and physiologic differences between the tissues and organs of man, and of dog or cat. The methods have to be modified according to these differences. In vascular surgery, every detail has a great importance, for a small fault of technic can produce fatal accidents. But it is certain also that these accidents do not happen when a very precise method is used. Perhaps it will be possible to utilize some day in clinical surgery some of the experimental results that we obtained.

It is proved by the experiments made at the Rockefeller Institute that the remote results of the transplantation of fresh vessels can be perfect, and that arteries, kept for several days or weeks outside of the body, can be transplanted successfully, and that after more than one year the results remain excellent. It has been shown, also, for the first time, that transplanted kidneys functionate, that an animal, having undergone a double nephrectomy and the transplantation of both kidneys from another animal, can live normally for a few weeks, and that an animal which has undergone a double nephrectomy and the graft of one of his own kidneys can recover completely and live in perfect health. Finally, it has been demonstrated that a leg extirpated from a dog and substituted for the corresponding leg of another dog, heals normally. These new facts are the results of the experiments performed during the last two years. Therefore, it is too soon to know what might be their practical value.

SOME PHYSIOLOGIC ASPECTS OF BLOOD-VESSEL SURGERY.

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INTRODUCTION.

The subject of blood-vessel surgery is not new. For many years surgeons have occasionally been called on not only to repair traumatic or pathologic injuries in the walls of arteries and veins, but also to unite the ends of cut vessels. An excellent review of the literature has been given by Murphy.[1] Among recent investigators and successful operators in this field, two of the leaders whose methods and results are known to all are present to-day. I refer to Drs. J. B. Murphy and Rudolph Matas. Their success has been due primarily to their refined technic, which essentially comprises the admixture of judgment and skill together with the employment of instruments and materials in accordance with the structures operated on. Dr. Tuholske tells me of successful results he has obtained by suturing blood vessels. No doubt there are other surgeons present who could likewise demonstrate successful results. Since success in this field has been achieved by a number of gentlemen present, it is with some trepidation that I present my views.

METHOD.

The technic employed in my experiments is a modification of that developed by Dr. Carrel and myself. Es-

1. Murphy, J. B.: Resection of Arteries and Veins Injured in Continuity End-to-End Suture, Med. Rec., Jan. 16, 1897.

sentially it is the same as that employed by previous successful investigators in that it consists of gentle handling of the vessels, with protection from drying, smooth approximation of the intimal surfaces and fixation by means of needles and thread in proportion to the size of the vessels.

After exposing the vessel, temporary occlusion is obtained by means of ordinary seraffine or bulldog forceps. By shielding the blades with muslin and forcibly compressing the springs to weaken them, the forceps may readily be adapted for use with liability of the vessel to injury reduced to a minimum. The edges to be sutured are cut smoothly with small sharp scissors. Excess of blood is removed by stripping the vessel between the fingers from the point of occlusion to the cut end and the blood absorbed with a soft dry sponge. The loose connective-tissue coat is then slightly stretched by grasping between the thumb and finger and snipped off even with the ends of the vessel. To protect the vessel from drying it is coated inside and out with paraffin oil. Two or more ligatures are then passed through corresponding points on the circumferential margins of the two ends of the vessel and tied, thus approximating the cut surfaces. The walls are then further united by a continuous suture entirely encircling the point of union, each stitch passing through the intima on either side a little way from the cut edge. The chief difference in the methods for arteries and veins is that in arteries the stitches are placed somewhat closer together than in veins. To facilitate handling and to aid in restraining coagulation, the threads are kept in paraffin oil. The needles employed on small and medium-sized vessels are No. 16 cambrics. The thread is one of the six component strands of Chinese twist silk. On restoring the circulation hemorrhage will occur from the needle-holes, but if the point of anastomosis be compressed for a minute or two, as a rule all hemorrhage ceases, due to the

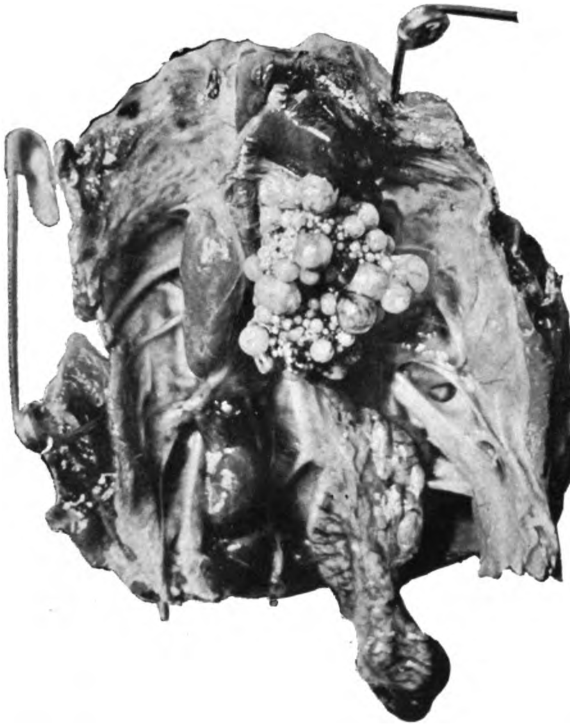

Fig. 1.—Ovary transplanted in fowl after about seven months. Eggs from such hens have been hatched.

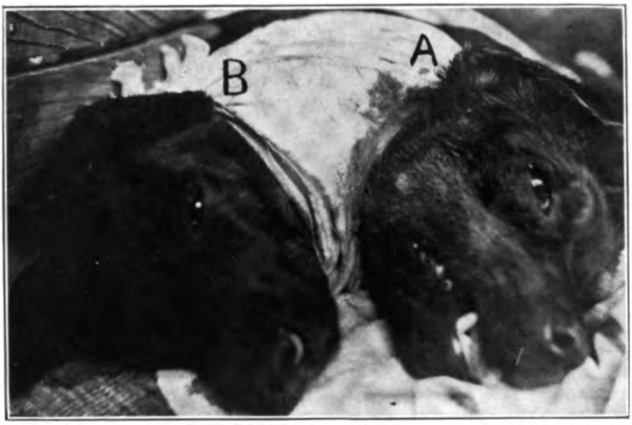

Fig. 2.—A, dog's head about one and one-half hours after being transplanted on to B. Reflex and voluntary movements good.

Fig. 3.—Kidney of male cat transplanted into a female cat for about one year.

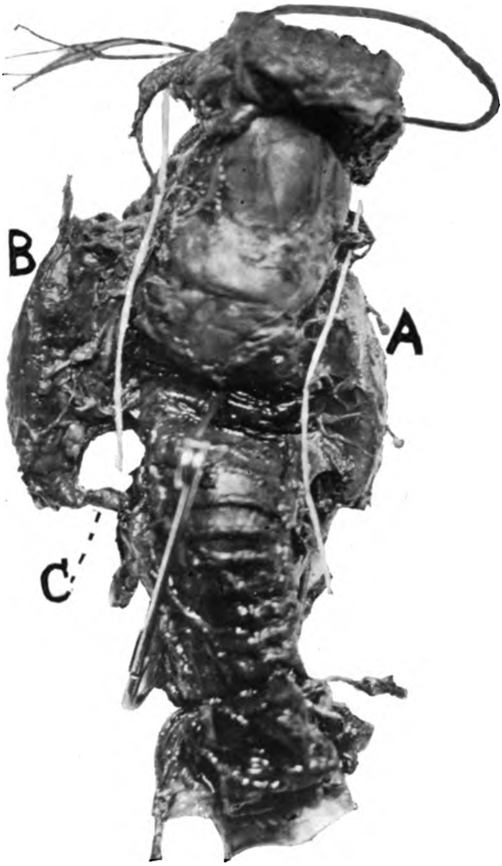

Fig. 4.—Enlargement after six days of normal thyroid gland (dog) following reversal of the circulation in right inferior thyroid vein. A, normal lobe; B, lobe on side operated on; C, anastomosis between the central end of the right common carotid artery and the peripheral end of the right inferior thyroid vein.

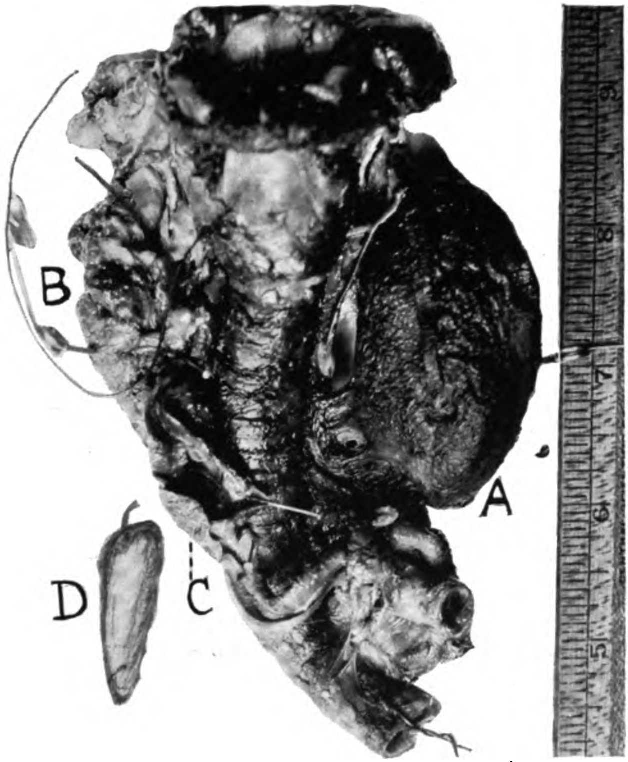

Fig. 5.—Decrease in size, after 11 months, of lobe of pathologic thyroid gland (goiter, dog) following reversal of the circulation in the right inferior thyroid vein. A, lobe on unoperated side; B, lobe on operated side; C, anastomosis between the central end of the right common carotid artery and the peripheral end of the right inferior thyroid vein.

deposit of fibrin in the holes. This technic can no doubt be improved, but for our present purposes it has been entirely adequate.[2]

Transverse or lateral injuries in the walls of both arteries and veins are readily repaired by picking the vessel up by placing the finger beneath the point of injury and stitching the edges of the wound directly, slight traction by the finger being adequate to compress the walls and shut off the circulation.

RESULTS.

Immediately after the operation, in all cases very probably, more or less fibrin is deposited inside the vessel at the point of anastomosis. This may be due: (a) to incomplete approximation of the intimas; (b) to holes in the intima due to the needle punctures; and (c) to the presence of the suture, which is foreign material, inside the vessel. Conditions are favorable for clotting at the point, as it is probable that blood plates tend to accumulate on the roughened surfaces (Kemp); and as they are known to furnish a factor (thrombogen) necessary in the formation of fibrin ferment (thrombin); and since the injured vessel walls provide another factor (thrombokinase); and since calcium, the other factor necessary for the formation of the ferment, is present in the plasma, conditions are favorable for coagulation. The extent of the resulting obstruction to the circulation may vary from practically nothing to complete stoppage, depending on the degree of perfection of the operation.

Unless there be some gross fault, the usual result is that no appreciable interference to the circulation results, and the fibrin deposited disappears, presumably by becoming organized and absorbed. The percentage of successful results depends somewhat on the size of the vessels, very small vessels being less successfully united.

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2. The Journal A. M. A., March 28, 1908, L, 1035.

Vessels having a diameter of 2 mm. or less are not so easily handled successfully as larger ones.

RESTORATION OF CONTINUITY OF DIVIDED BLOOD VESSELS.

If vessels be merely divided without great loss of substance the ends may be reunited directly, owing to their elasticity. Excessive traction on the anastomosis is to be avoided, as it renders success less certain. Traction may be lessened by suitable ligatures connecting the tissues surrounding the vessels. Where the gap is too large a variety of measures are at the disposal of the operator. Perhaps the most feasible is to remove a suitable segment of some non-essential vein and interpose it between the ends of the divided vessel. Or a segment of blood vessel from another animal of the same or of a different species may be employed. Or a segment of vessel previously removed and kept at a low temperature[3] or in a preserving solution—formaldehyd, for instance[4]—may be used with good result. Functionally, all of these methods have given excellent results. Even though enormous structural alterations may occur in such segments, no evidence of loss of adequate physical strength has been observed. As a rule, fibrous thickening of the wall occurs.

A number of factors must be taken into account in interpreting the structural changes. As these have been dealt with in a previous paper,[2] I shall not take them up in detail here.

TRANSPLANTATIONS OF ORGANS.

The old and well-known method of grafting tissues answers in the higher animals only for small masses of tissues. In the case of birds, even ovaries may thus be successfully transplanted[5] (Fig. 1), but in the case of

3. Carrel, Alexis: Heterotransplantation of Blood Vessels Preserved in Cold Storage, Jour. Exper. Med., March 14, 1907, ix, 226-228.

4. Guthrie: Transplantation of Formaldehyd-fixed Blood Vessels, Science, N. S., 1908, xxvii.

5. Guthrie, C. C.: Further Results of Transplantation of Ovaries in Chickens, Jour. Exper. Zool., 1908.

large organs, or masses of tissues such as a limb, the method is inadequate.

Since anastomosis of blood vessels has proved so simple a matter, I have employed it in studying the latter class of transplantations. Briefly, the results so far have demonstrated the feasibility of transplanting limbs. That the restored circulation is adequate is demonstrated by the absence of gangrene or other symptoms attributable to this factor both in the case of a hind leg replanted on a dog by Carrel and myself, and also by both fore and hind legs which I have transplanted from dogs to dogs of other breeds. In addition, I have transplanted dogs' heads with preservation of cerebral and bulbar function (Fig. 2). Even in a case in which the circulation was interrupted for twenty-nine minutes, good return of function was observed in the transplanted head. This demonstrated conclusively the adequacy of the restored circulation.

Since I have found no evidence of serious derangement of metabolism in dogs' thighs up to eleven days after transplantation, nor in a dog's fore leg six days after transplantation, and since there are no physiologic or other reasons known why such tissues as those found in the limb may not live and again function under such conditions, it seems justifiable to conclude that it is possible to transplant such a member with permanent success.

In the case of tissues less resistant to the interference to the circulation necessary during the period of the operation, our present knowledge is more limited owing to lack of exact data. Also in operations of such length that coagulation of the blood in the vessels of the part being transplanted is liable to occur, in which we have been in the habit of washing the blood out with some one of the many inappropriately termed "physiologic saline solutions," the extent of the injurious action of the solution is unknown. From the results on the kidneys, although my animals lived for several weeks, I

came to the conclusion that permanent success was improbable owing to the latter factor. Even in the case of a kidney transplanted into a cat for more than a year, removal of the sound kidney was promptly followed by death of the animal. Examination showed the transplanted kidney to be structurally far from normal (Fig. 3). This may have been due, however, at least in part, to other causes. A partial washing out of the blood will not eliminate this factor of toxicity of the solution, for when the solution arrives at the capillaries through which it must pass in order to displace the blood from the veins, it will be practically unmixed with blood, for the well-known reason that after the circulation is cut off the arteries tend to empty themselves. As in all probability it is in the capillaries that the greatest harm is done, the notion of judging partial perfusion by the degree of dilution of the blood as it escapes from the veins is theoretically incorrect.

It is now known that it is possible to transplant the legs or heads of dogs so quickly that perfusion is unnecessary, coagulation not occurring under forty minutes to one hour or more, and the period of occlusion requiring not over thirty minutes.

No doubt the time of occlusion in transplanting such organs as the kidneys may also be reduced so that danger of clotting will be eliminated. For the present, however, I am investigating the influence of various solutions used for perfusion, as well as the effect of clamping the arteries on the kidneys. To do this I clamp the aorta immediately above and below the origin of the renal arteries. When perfusion is desired, this is accomplished by means of a needle inserted into the segment of aorta between the clamps. By clamping in addition the renal artery on one side, the perfusion may be confined to one kidney while the other is simply cut off from the circulation. Thus far I have used cats, and the results on these animals are striking. When perfused with even relatively small quantities (5 to 15 c.c. per

kidney) of 0.9 NaCl or Locke's or other so-called "physiologic salt solutions" for periods of only a few minutes, the total period of occlusion not exceeding ten to fifteen minutes, often death occurs within three to ten days with symptoms of a uremic toxemia and derangement of renal internal secretion, as evidenced by the rapid emaciation and enormous amounts of urea excreted.[6]

RESULTS ON THE CIRCULATION OF SURGICAL INTERFERENCE.

It has been known for a very long time that the activities of the tissues of the body may be profoundly influenced by alterations of the circulation. This consists of decreasing or increasing the blood to a part. Decreasing the circulation brings about the condition termed "anemia;" increasing the circulation produces "hyperemia." Tying an artery will produce anemia; increasing the arterial flow to a part as by causing a local dilatation produces active hyperemia, while by hindering the venous return passive hyperemia will be produced. It is especially in connection with the latter condition, that is, hyperemia, that I desire to present very briefly a few experimental results.

The magnitude of the changes observed in normal tissues after production of a localized hyperemia is in direct proportion to the degree of hyperemia. By reversing the circulation in the peripheral end of one of the external jugular veins by anastomosing it with the central end of one of the common carotid arteries, no doubt a degree of passive hyperemia of the head is produced; yet no evidences of this are observed in the behavior of the animal, and no marked structural changes have been observed other than a thickening of the wall of the vein. The lack of more positive results is probably due to the free anastomosis of the veins with other veins.

6. Bradford: Proc. Royal Sic., London, 1892; Tigerstedt and Bergmann; Skandin. Arch. f. Physiol., 1898, viii, 223; Suner: Zentralbl. f. d. ges. Physiol. u. Path. d. Stoffwechs., 1907, 2, 3.

No.	Date.	Aorta Occluded.	Perfusion Made.	Amount Perfused, c.c.	Aorta Released.	Period of Occlusion.	Period of Perfusion.	Remarks.	Perfused with	Death after
16	4, 24, '08	3:54	3:56	31	4:07	13' 0"	11' 0"	Both kidneys perfused.	Ringer's sol	3 days.
*17	4, 25, '08	1:54	1:56	25	2:07	13' 0"	11' 0"	Both kidneys perfused; nerves cut	Ringer's sol	9 days.
18	4, 29, '08	4:15' 30"	4:17' 30"	21	4:26' 30"	9' 0"	7' 0"	Both kidneys perfused.	Ringer's sol	1 day.†
19	5, 7, '08	3:32	3:35	40	3:45	13' 0"	10' 0"	Right kidney *only*, perfused.	Ringer's sol .	3 days.
20	5, 7, '08	4:34	4:39' 30"	18	4:48	14' 0"	8' 30"	Both kidneys perfused.	Ringer's sol .	2 days.
21	5, 23, '08	2:35	2:38	11	2:50	15' 0"	12' 0"	Both kidneys perfused	Locke's sol. .	3 days.

* Analysis of urine: Amount, 30 c.c.; color, pale yellow, cloudy; sp. gr., 1.048; sugar, absent; proteids, trace; urea, 11.28 %; chlorids, large quantity; phosphates, large quantity; sulphates, large quantity; microscopic examination shows several casts; many spermatozoa.

† Clot in aorta.

If, however, the circulation be similarly altered in a vein having a more "terminal" character, as in the inferior thyroid vein, the results are striking. This operation produces what may be termed a double hyperemia, as by eliminating the vein as a channel for return of venous blood, the ratio of venous to arterial cross sectional area of the gland is decreased; therefore, passive hyperemia results. But since arterial blood is forced into the

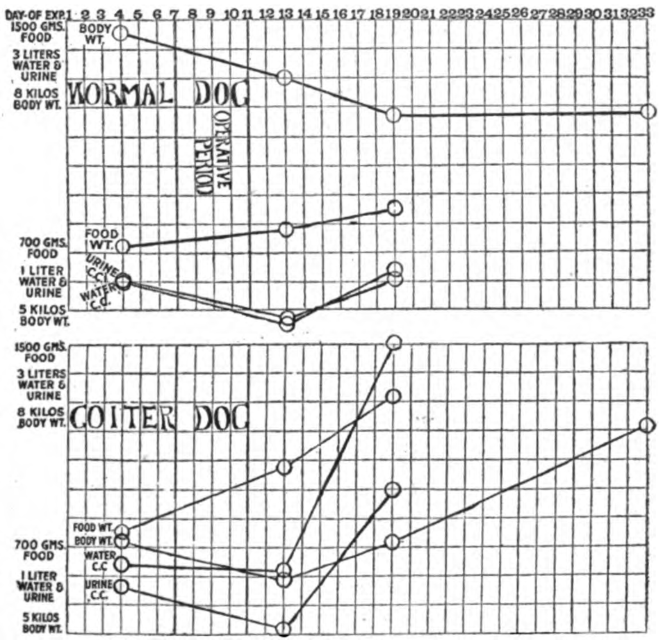

Fig. 6.—Chart showing metabolism of dog before and after operation on goiter.

gland through the vein, the proportion of arterial area to venous areas is further increased, and active hyperemia is also produced. Such an operation produces a maximum hyperemia, and the results on both normal and pathologic glands are very marked. In both cases a rapid transudation is seen to take place from the blood vessels, the glands becoming markedly edematous even in a few minutes. The swelling increases for about forty-

eight hours, by which time, in pathologic glands, it may reach enormous proportions (Fig. 4). At the end of this period it begins to subside, so that at the end of about twelve days the gland is about the same size as at the time of operation. In the case of enlarged pathologic glands, from this time onward there is a continuation of decrease in size so that at the end of three weeks or a month the gland may not greatly exceed a normal gland in size (Fig. 5). The chief clinical difference in the reaction thus set up in a normal and pathologic gland is of degree. Also, it seems that the normal gland does not decrease to below its size at the time of operation.

Ligation of the thyroid veins in pathologic glands is followed by a similar train of clinical phenomena to that described above, the difference again being one of degree.

The accompanying chart (Fig. 6) shows the result of a few observations on the gross metabolic processes in a dog before and after production of double hyperemia in one side of a bilaterally symmetrical goiter. Among these results are an increasing appetite and thirst and a corresponding increase in body weight. In behavior and physical condition the results have been equally striking, the animal having become lively and lost the appearance of a sick dog. These changes are no doubt due primarily to the increase in capillary pressure, this resulting in the passage of liquid from the blood into the extravascular spaces. Beyond this we enter the realm of speculation, and, since Dr. Tuholske will have something to say on this point to-morrow, I refrain from further discussion.

1806 Locust Street.

THE STATISTICS OF ENDOANEURISMORRHAPHY, OR THE RADICAL CURE OF ANEURISM BY INTRASACCULAR SUTURE.

SUMMARY OF CASES REPORTED UP TO JUNE 1, 1908.

RUDOLPH MATAS, M.D.
NEW ORLEANS.

In 1902 I reported to the American Surgical Association, at its meeting in Albany, the first five cases of aneurism treated by this method, which were then described for the first time. The first case dated as far back as March 30, 1888, a little more than twenty years ago. In the transactions of the same association for 1895 the list was increased to 24 operations performed by 15 different operators. At the fifty-seventh annual session of this association, held in Boston, June 1, 1906, I was able to report 34 operations performed by this method by 21 American operators,[1] and now (June 3, 1908) I am able to report a total of 85 cases treated by 52 surgeons, of whom 49 are American and 3 foreign. Thus, within the space of six years, since my first systematic description of the method of intrasaccular suture, the list has increased from 5 to 85 observations—a most gratifying increase, when we consider the comparative rarity of surgical aneurism in civil life, and the fact that the method suggested was a radical departure from the classical and accepted methods of practice.

For the liberal recognition given by the profession to the suggestions which I have had to offer and the generous encouragement which I have received, I am

1. See, for references to this and previous contributions by the author, THE JOURNAL A. M. A., Sept. 29, 1906, xlvii, 990-933.

duly grateful, and I avail myself of this opportunity to publicly acknowledge my indebtedness to the many correspondents, collaborators and colleagues whose valued contributions, friendly criticism and sympathetic commendation have alone made possible the compilation of the convincing mass of evidence which I have now the honor to submit to you. I fervently trust that whatever the future may have in store for the cure of aneurism, the final judgment may be that the fundamental ideas which underlie the method of treatment here advocated are sound and conducive to surgical progress. In the short time allowed for this discussion I shall not attempt to make any comparative statement of the relative merits of endoaneurismorrhaphy as contrasted with other methods of treating aneurism, or engage in any controversy in reply to any criticisms or commentaries which have come from various sources, and which, whether favorable or otherwise, I appreciate with due deference, but can not now consider with propriety, as the limitations of time will only permit of the presentation of the facts, which I trust will speak for themselves.

SYNOPSIS.

Total number of cases (arteriovenous aneurism excluded)	85
Total number of operators	52
Typical operations	77
Atypical operations	8
American operators	49
Foreign operators	3

GEOGRAPHICAL DISTRIBUTION.

United States and Canada.

State and City.	Operators and No. Cases.	Total.
Alabama:		
Birmingham	George S. Brown, 1	1
California:		
San Francisco	Thos. W. Huntington, 1; Stanley Stillman, 1 (atypical)	2
District of Columbia:		
Washington	James F. Mitchell, 1; George T. Vaughan, 1 (atypical)	2

Georgia:
Atlanta—F. W. McRae, 1.
Savannah—Craig Barrow, 4; Geo. S. White, 2. 7
Illinois:
Chicago—Charles E. Humiston, 1; Carl Beck, 1 2
Indiana:
Indianapolis—H. O. Pantzer, 1.............. 1
Kansas:
Jetmore—Anson B. Ingells, 2................ 2
Kentucky:
Lexington—W. O. Bullock, Jr., 4.
Lebanon—R. C. McChord, 1................ 5
Louisiana:
New Orleans—Matas, 8; Danna, 7; Stafford, 3; Gessner, 2; Parham, 1; Martin and Parham, 1 (atypical); Kohlman and Newman, 1; Perkins, 1; S. P. Delaup, 1 (atypical) 26
Massachusetts:
Boston—J. C. Munro, 2.................... 2
Mississippi:
Natchez—J. G. Lilly, 1 (atypical).......... 1
Missouri:
Kansas City—J. F. Binnie, 3; W. J. Frick, 1.. 4
North Carolina:
Wilmington—Thomas W. Green, 1............ 1
New York:
New York—Robert T. Morris, 1; Willy Meyer, 1; Robert Abbe, 2; F. H. Markoe, 1; W. Blake, 1................ 6
Pennsylvania:
Philadelphia—Frazier, 3; Gibbon, 2; Da Costa, 1; Stewart, 1; Van Lennep, 1. 6
Rhode Island:
Providence—James W. Keefe, 1.............. 1
Tennessee:
Memphis—M. Goltman, 2 2
Virginia:
Norfolk—Levi Old, 2; L. Brown, 1........... 3
Washington:
Tacoma—James R. Yocom, 1.
Puget Sound—D. N. Carpenter, 1............ 2
Canada:
Montreal—J. M. Elder, 1................... 1

Total in United States and Canada.......79

FOREIGN.

Spain:

Saragossa—R. Lozano, 4 4

Italy:

Naples—G. Del Conte, 1.

Venice—D. Giordano, 1 (atypical) 2

Total of foreign 6

Grand Total 85

ANATOMIC DISTRIBUTION.

TYPICAL AND ATYPICAL.

Abdominal aorta	2	External carotid	1
External iliac	1	Subclavian	1
Gluteal	1	Subclavio-axillary	2
Iliofemoral	5	Axillary	1
Femoral	18	Brachial	2
Popliteal	50		
Posterior tibial	1	Total	85

Over 58 per cent. popliteal; over 21 per cent. femoral.

TYPES OF ENDOANEURISMORRHAPHY.

OBLITERATIVE, FIFTY-NINE CASES.

Popliteal (4 atypical)	32	External iliac	1
Femoral (1 atypical)	12	Posterior tibial	1
Iliofemoral (2 atypical)	4	Gluteal	1
Abdominal aorta	2	External carotid	1
Subclavio-axillary	2	Subclavian	1
Brachial	2		

RESTORATIVE, THIRTEEN CASES.

Popliteal	8	Femoral	5

RECONSTRUCTIVE, THIRTEEN CASES.

Popliteal	10	Iliofemoral	1
Femoral	1	Axillary	1

		Per cent.
Total obliterative	59	69.3
Total reconstructive	13	15.4
Total restorative	13	15.4

Popliteal, 50 cases. Obliterative (typical), 28 cases.

POPLITEAL, FIFTY CASES.

OBLITERATIVE (TYPICAL), TWENTY-EIGHT CASES.

R. Matas	4	F. W. Parham	1
J. A. Danna	3	R. Abbe	1
W. O. Bullock, Jr	2	J. C. Da Costa	1
Craig Barrow	2	Randall Hunt	1
H. B. Gessner	2	C. E. Humiston	1
S. W. Stafford	2	T. W. Huntington	1
J. H. Gibbon	2	J. W. Keefe	1
George C. Miller	1	W. Blake	1
L. Lozano	2		

ATYPICAL CASES.

S. Stillman	1	J. D. Lilly	1
S. P. Delaup	1	Carl Beck (?)	1

POPLITEAL RECONSTRUCTIVE EIGHT CASES.

Hugo O. Pantzer	1	R. C. McChord	1
J. F. Binnie	1	Anson B. Ingells	1
C. H. Frazier	1	F. T. Markoe	1
W. Meyer	1	M. Goltman	1

POPLITEAL RECONSTRUCTIVE TEN CASES.

Craig Barrow	1	I. Brown	1
J. F. Binnie	2	J. R. Yocom	1
J. A. Danna	1	W. J. Frick	1
Robert Morris	1	F. T. Stewart	1
G. A. Van Lennep	1		

Stafford........................1 death (tetanus).
Stafford, Lozano.................2 cases, gangrene.
Morris, Danna, Binnie..3 relapses, all reconstructive operations).

Secondary Hemorrhage—Binnie's third case, six weeks after suture and four weeks after ligature of superficial femoral. Recovery after amputation.

Two obliterative operations (Matas and Craig Barrow) were performed after spontaneous gangrene of the foot had occurred; the operations were undertaken with the hope of arresting further progress of gangrene, by relieving tension in the popliteal space and thereby improving the chances of the collateral circulation. Recovery after amputation of leg in both instances.

FEMORAL ANEURISM.

Typical, 17; atypical, 1—total, 18.

OBLITERATIVE, ELEVEN CASES.

R. Matas	1	J. F. Mitchell	1
J. A. Danna	2	George S. Brown	1
W. O. Bullock	2	T. M. Green	1
C. H. Frazier	1	S. W. Stafford	1
D. N. Carpenter	1		

RESTORATIVE, SIX CASES (ONE ATYPICAL).

George R. White	2	J. M. Elder	1
Kohlman & Newman	1	G. Del Conte (atypical)	1
		M. Goltman	1

Reconstructive, 1........................Craig Barrow
Death, 1 ....Stafford
Gangrene, 2 ....Stafford, Frazier
Secondary hemorrhage, 0.
Relapses, 0.

ILIOFEMORAL ANEURISM, FIVE CASES (TWO ATYPICAL).

OBLITERATIVE, FOUR CASES (TWO ATYPICAL).

Matas, 1 (recovery).
Levi Old, 1 (hemorrhage, secondary ligature of iliac, gangrene, exhaustion, death).
Atypical, 2 cases.
G. T. Vaughan, 1 (ligature, recovery from operation; death in 4 months from heart disease).
D. Giordano, 1 (recovery).

RECONSTRUCTIVE, ONE CASE.

Danna, 1 (relapse, rupture, death).

EXTERNAL ILIAC.

Levi Old, 1, obliterative (death from pulmonary embolism).

ABDOMINAL AORTA.

J. C. Munro, R. Lozano, 2, obliterative (death from shock, hemorrhage).

POSTERIOR TIBIAL.

W. M. Perkins, 1, obliterative (recovery).

GLUTEAL.

Robert Abbe, 1, obliterative (recovery).

EXTERNAL CAROTID.

Floyd McRae, 1, obliterative (recovery).

SUBCLAVIAN.

Martin and Parham, 1, atypical, obliterative (recovery).

SUBCLAVIO-AXILLARY.

J. C. Munro, R. Lozano, obliterative (recovery).

AXILLARY.

Anson B. Ingells, 1, reconstructive (recovery).

BRACHIAL.

Matas, 2, obliterative (recovery).

RESULTS.

Total, 85 cases; 78 recoveries and 7 postoperative deaths; secondary hemorrhage, 2; gangrenes, 4; relapses, 4 (all in reconstructive cases).

The 7 deaths are detailed as follows:

I. Obliterative Group (59 cases).	
Abdominal aortic (Lozano and Munro)	2
External iliac (Levi Old)	1
Iliofemoral (Levi Old)	1
Femoral (Stafford)	1
Popliteal (Stafford)	1
Total	6
II. Restorative (13 cases)	1
III. Reconstructive (13 cases) (Danna); deaths	1
Total deaths	7

SECONDARY HEMORRHAGE.

I. Obliterative (59 cases)	2
Iliofemoral (Levi Old)	1
Popliteal (Binnie)	2
II. Restorative (13 cases)	1
III. Reconstructive (13 cases)	0

GANGRENE OF PERIPHERAL PARTS.

I. Obliterative (59 cases)	4
Popliteal (Stafford, Lozano)	2
Femoral (Frazier)	1
Iliofemoral (Levi Old)	1
II. Restorative (13 cases)	0
III. Reconstructive (13 cases)	0

RELAPSES.

I. Obliterative (59 cases)	0
II. Restorative (13 cases)	0
III. Reconstructive (13 cases)	4

Popliteal (Morris)..............1 (amputated; recovery).
Popliteal (Danna)....1 (cured by secondary obliterative).
Popliteal (Binnie)..............1 (amputated; recovery).
Iliofemoral (Danna)...............1 (ruptured; death).

COMMENTARIES.

Mortality.—To sum up the review of the mortality, if we eliminate the two aortic cases of Lozano and Munro, the popliteal of Stafford (tetanus); the femoral of Stafford (rupture of secondary aneurism, ligature of

iliac, gangrene and sepsis), the external iliac of Levi Old (pulmonary embolism), five would be eliminated from the list, leaving two which can be directly charged to the operative procedure, or, at least, as direct postoperative sequences. The legitimate mortality, thus reduced from 7 to 2 deaths in 85 cases, would be equivalent to 2.3 per cent.; secondary hemorrhage, 2 in 85 cases, or 2.3 per cent.; gangrene, 4 in 85 cases, or 4.6 per cent. If we eliminate Lozano's and Stafford's popliteal cases, in which the vein was simultaneously injured and ligated; and Levi Old's iliofemoral, in which gangrene followed the secondary ligature of the external iliac, the percentage of gangrenes legitimately attributable to the intrasaccular operation would be one in 85, or 1.1 per cent.

Relapses.—These occurred only in the reconstructive operation; four in thirteen, or 28.9 per cent., to the total, 4.7 per cent. It is to be noted that, in one of these cases the aneurism was cured permanently after the relapse by a secondary obliterative operation (popliteal, Dana), and from a previous knowledge of the conditions existing in the sac in two other cases, one popliteal (Morris) and one iliofemoral (Danna) there is every reason to believe that a similar cure could have been effected if an obliterative operation had been performed after the relapse had been recognized. In only one case (Binnie's popliteal) the local conditions would have been apparently unfavorable to any local intervention.

In closing this brief summary of the results thus far obtained by the method of endoaneurismorrhaphy, I would state that there are many important and hitherto undescribed details in the anatomy and morphology of aneurismal sacs, as well as their various modes of development, which have become apparent since the advent of this method has compelled the operating surgeon to examine the interior of the aneurismal cavities in order to determine the technic required for

each individual case. In fact, I believe that a new chapter in the study of aneurism has been added as a result of the opportunities offered by this method of procedure.

The conclusions drawn from this study (which will be published later) will be of decided practical value in the application of the technic. I believe that the fundamental principle on which this operation is based, viz., that the endothelial lining of the vascular system which is continued in the aneurismal sac, is analogous in its pathologic behavior to the reactions and reparative processes which occur in the endothelial surfaces of other serosæ, such as the peritoneum and the pleura, has been absolutely confirmed by the mass of evidence presented in these eighty-five operations.

Another fundamental conclusion arrived at after a study of the restorative and reconstructive cases is that the law of Scarpa (1817), the great master of Pavia, to the effect that "a complete and radical cure of aneurism can not be obtained in whatever part of the body this tumor is situated unless the ulcerated, lacerated or wounded artery from which the aneurism is derived is, by assistance of Nature or of Nature combined with Art, obliterated and converted into a perfectly solid ligamentous substance"—a dictum which for nearly a century has never been disproved—is now challenged by the experience of this method in its restorative and reconstructive types. The conclusion is likewise supported by modern experimental research, which has fully demonstrated the successful suture and resection of arteries with complete restoration of the lumen of the artery and the functional integrity of the sutured vessel. All honor to Murphy and Carrel and the great company of distinguished workers who have followed in their footsteps in demonstrating this fundamental fact of such vital importance to the progress of vascular surgery. However, let us not forget that we owe largely to the genius and sagacity of Scarpa one of the earliest and

most convincing statements of the doctrine of the unity of the serosæ and of the endothelial surfaces in their specific reactions when subjected to irritation.

It is the tardy recognition of this great truth, in the operation here advocated that has made the plastic obliteration of sutured aneurismal orifices and of aneurismal cavities as much a matter of common experience as the adhesion and plastic union of opposed serous surfaces when sutured, is the fundamental and unfailing experience of the abdominal surgeon.

There are also points in the technic that have been recently elaborated, and of these the mode of obliterating the sac in special cases, according to pathologic conditions or topographic or regional requirements are important. One of the features of the technic of the greatest importance is that of prophylactic hemostasis, which must be made absolute if a deliberate and carefully planned technic is to be carried out. In regard to preventive hemostasis I must state that the problem increases in complexity and difficulty as the aneurism to be attacked approaches the root of the limbs and the neck where constriction is impracticable. This preliminary control of the circulation by obtaining a mastery of the great regional trunks in order not only to control the direct circulation in the aneurism but that which is supplied by the collateral vessels, still remains in the treatment of aneurisms by the intrasaccular methods as good and thorough a test of the training and resources of a surgeon as it ever was in the days of the ligature and of extirpation.

To illustrate what is meant, I need only consider the difficulties in the way of completely controlling the circulation in high femoral, iliofemoral and iliac aneurisms in which the opening of the sac may be followed by the most formidable and even fatal hemorrhage if the inexperienced operator has trusted for prophylactic hemostasis to the compression or temporary ligation of the parent artery immediately above and below the sac.

The cases of femoral aneurism reported by Frazier and Mitchell are good illustrations of the fallacy of such procedures and of the fact that it was only the resourcefulness and skill of these brilliant surgeons that averted a calamity that would have surely followed in less able hands. The difficulty in controlling the hemorrhage lies in the fact that numerous and complete collateral branches open into the parent trunk at its junction with the sac, or empty into the sac itself in the intermediary space between the inlet and the outlet of the aneurism. In femoral, iliofemoral and iliac aneurisms of large size and of the fusiform type the control of the parent trunk immediately above and below the sac is of no avail; to operate bloodlessly the great vessel commanding the entire collateral supply of the limb must be compressed. In these cases it is only by compression and control of the common iliac through an abdominal incision that the collateral hemorrhage from the obturator, sciatic, pudic and gluteals can be controlled.

In a case of iliofemoral aneurism which recently came under my observation even the compression of the common iliac and of the abdominal aorta at the bifurcation, was not sufficient to secure an absolutely dry field. On opening the sac, which had apparently collapsed after direct compression of the common iliac, blood spurted out in a considerable stream, which was found to come from a well-developed epigastric. This could not be controlled by the direct compression of the common iliac or of the abdominal aorta. It was only by direct pressure on the bleeding orifice in the sac and its direct occlusion with a clamp that the bleeding was arrested and that the technic was carried out to completion with safety and deliberation. However, the temporary compression of the common iliac, which controls all the branches of collateral importance given by its internal branch is sufficient, as a rule, to secure a safe, if not an absolutely ischemic field in the majority of cases.

In the upper extremity the hemostatic problem increases in gravity as we approach the axilla and the subclavian areas. In axillary aneurism the third division of the subclavian should be controlled, while an elastic bandage applied to the arm as near as possible to the lower pole of the sac prevents the lower collaterals from feeding the aneurism after it is opened. The circulation in the right subclavian should be controlled by a preliminary compression of the innominate and, on the left side, by the first division of the subclavian.

In carotid aneurisms there are two problems to consider, the hemostatic problem and the secondary effects on the brain of an obliterative operation. In all these cases, especially in the pathologic aneurisms, and those which occur in all subjects above 40, the efficiency of the collateral circulation in nourishing the brain should be tested by temporary methods of occlusion, which must not damage the artery after remaining *in situ* over 48 hours while the patient's cerebral circulation is kept under observation. Here Dr. Halsted's ingenious aluminum bands, Crile's or other clamps, or the temporary protected ligatures of Jordan and Doberauer may be applied with advantage. The danger of embolism following the restoration of the circulation after the application of these tests is to be especially feared in cases of carotid aneurism; and it is a question that is yet undecided whether it is not the better plan to limit the temporary occlusion to the internal carotid above the bifurcation and beyond the sac so that while the collateral circulation through the circle of Willis is being tested, the circulation in the aneurism itself is not interfered with sufficiently to favor the liberation of an embolus, should the release of the constriction become necessary.[2] I have recently found that with a simple

2. The value of the *temporary* occlusion of the common or internal carotid for forty-eight hours, as a preliminary test of the competence of the cerebral circulation prior to the permanent occlusion or extirpation of these vessels, is based on the fact that cerebral disturbances occur as a rule immediately or a few hours after the carotid circuit has been interrupted. Usually, character-

silver wire band gradual or total compression can be applied to the carotid or any other vessel by using a minute metal clip which holds the wires together in parallel rolls and adjusts the compression very easily to any desired degree. The great desideratum in every case is to apply a device which will control the circulation in the vessel absolutely, without damaging the internal tunics and which can be removed at any time within the test period (forty-eight hours) should danger symptoms appear in the brain or in the peripheral parts when aneurisms in the limbs are being considered. This is admirably accomplished by Halsted's bands when applied as a means of partial or total occlusion as a primary procedure. But the expertness required in properly adjusting them and rolling them around the artery, or unrolling them when this may be required, without damage to the vessel, make it desirable that a simpler means of carrying out Dr. Halsted's admirable principles be adopted.

In conclusion, our experience demonstrates that in all sacciform aneurisms with a single orifice of communication, the closure of this orifice by suture without interfering with the lumen of the artery or its blood-carrying function, should be regarded as an obligate procedure of the operation. The indications, however, for the reconstructive operation in fusiform aneurisms with separate orifices of entrance and exit, must still be considered *sub judice*.

When is the reconstructive operation or arterioplasty in an aneurismal sac to be regarded as necessary or justifiable?

istic or premonitory cerebral disturbances appear within the first twelve or thirty-six hours, often *immediately* after the ligation. There are exceptional cases, however, in which postoperative hemiplegia and progressive signs of softening have appeared from one to three weeks after the ligation of the common carotid. These late postoperative brain complications are more likely to occur in suppurating or septic cases as the result of thrombosis or embolism. They were frequent in the pre-antiseptic period. Thus the patient on whom the first ligation of the common carotid for aneurism of this vessel (1805) was performed by Sir Astley Cooper, succumbed on the twenty-first day after the operation in a state of coma preceded by hemiplegia.

Without attempting to discuss with Binnie the special types of fusiform aneurism in which the reconstruction of an artery is more or less indicated, I will simply state that in the large majority of the reported cases of aneurism of the extremities, and especially of the popliteal and femoral (which furnish the most crucial test of the efficiency and safety of any radical method) the simple obliterative procedure proved thoroughly satisfactory in accomplishing its purpose without interfering with the vitality of the distal parts.

The evidence which has accumulated and which has been gathered in these reports, is sufficient to prove that in this respect the obliterative operation accomplishes the cure of the aneurism with less risk to the distal parts than either the ligature or the method of extirpation. This would now appear to be a proved clinical fact. The conditions which must determine in any given instance whether a reconstructive operation is indicated or an obliterative operation can be performed with absolute safety or not, will never be answered satisfactorily until an unerring clinical test of the adequacy of the collateral circulation after the preliminary compression of the main trunk which feeds the aneurism, will be at our command. The method of determining the peripheral blood pressure in the very tips of the extremities recently devised by the Russian surgeon, Korotkow, as the result of his experience with arteriovenous aneurisms in the Russo-Japanese war, and applied successfully by him, Petrov and v. Oppel,[3] may prove the final solution of the problem.

If the peripheral blood pressure is shown by the manometer to be more or less sustained after the compression of the main trunk above the aneurism, then the obliterative operation may be safely applied. If, on the other hand, the blood pressure falls to zero, it is evident that the collateral circulation is inadequate and that no chance should be taken with the obliterative

3. Von Oppel: Arch. f. Klin. Chir., 1908, lxxxv.

operation or with any procedure whatever (ligature, extirpation, etc.) which would permanently obliterate the parent artery. In these rare cases (as a rule, aged or advanced arteriosclerotic subjects) it may be the safer plan to limit the intervention to a *partial* occlusion of the main trunk with a constricting band on the proximal side, close to the aneurism, by the method suggested by Dr. Halsted, trusting that when obliteration finally takes place a collateral circulation may be developed sufficiently to preserve the vitality of the distal parts.

The objection to this plan is that, in advanced arteriosclerotic subjects, the collaterals do not develop for obvious reasons; and again, in other cases, that the operation may fail to cure owing to the persistence of the circulation in the sac. Furthermore, as in the case of the ligature, the persistence of the tumor, after obliteration of the main artery, when coagulation does take place, does not relieve the tension in certain confined and compressed spaces (as in the popliteal area), where the evacuation of the sac is necessary to improve the perianeurismal and the distal circulation.

One of the great advantages of the intrasaccular method is that the sac is thoroughly emptied of its contents and that the perianeurismal tension is at once relieved, giving not only better opportunities for the development of the collateral circulation, but also relieving the obstruction to the return venous flow, as is so apparent in many edematous and choked limbs in advanced cases of popliteal aneurism.

NOTE.—Surgeons who have had personal experiences with the intrasaccular method (endoaueurismorrhaphy) will greatly oblige me by communicating with me and furnishing clinical reports, which will be utilized in a further statistical study of the reported cases.

2255 St. Charles Avenue.

SUCCESSFUL LIGATION OF THE INNOMINATE ARTERY.

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Surgeon to the City Hospital; Division Surgeon to 'Frisco Railway.
MEMPHIS.

Valentine Mott, who performed the first operation for ligation of the innominate artery in 1818, says:

> Since the publication of Allan Burns' invaluable work on the surgical anatomy of head and neck, I have been in the habit of showing in my surgical lectures, the practicability of securing in a ligature, the arteria innominata; and I have had no hesitation in remarking that it was my opinion that this artery might be taken up for some condition of aneurisms and that a surgeon with a steady hand and a correct knowledge of the parts would be justified in doing it.

When the proper case presented itself to him he said further: "I could not for a moment hesitate in recommending and performing the operation."

METHOD OF CLASSIFICATION.

I am presenting for consideration five classes of cases tabulated as follows:

1. Cases in which the innominate artery alone was ligated for subclavian aneurism. In this class the arteries are necessarily diseased; and the case I present to you falls under this class (Table 1).

2. Cases in which the innominate, carotid and vertebral arteries were ligated for aneurism of the innominate, carotid and subclavian arteries. Here also the vessels are diseased and more than one vessel is ligated, an extra precaution against hemorrhage or return of the aneurism (Table 2).

3. Cases in which the innominate artery was ligated for secondary hemorrhage and in which the vessels probably were not diseased and greater prospects of repair might be expected (Table 3).

4. Cases in which the artery ligated is indefinite and reported as innominate ligations; also miscellaneous cases (Table 4).

5. Cases in which ligation of the innominate artery was attempted but in which the operation was not completed (Table 5).

In the first class of cases, if Burrell's case is counted as a recovery, we have 0.11 per cent. recoveries. If this case is regarded as unfavorable, then the case I present is the only recovery in this class and shows 0.55 per cent. recoveries.

In the second class a percentage 35.7 is shown.

In the third class 33.3 per cent of the patients recovered.

In the fourth class none recovered.

In the fifth class, strangely enough, we have a recovery percentage of 40 per cent.

Of the 46 cases actually accomplished, 15, or 32.5 per cent., were done in the United States of America and credited to the following cities: New York, 5 (Valentine Mott, Lynch, A. B. Mott, Bull, Curtis); Boston, 2 (Burrell, Gray); Philadelphia, 1 (Harte); San Francisco, 2 (Cooper, 2); New Orleans, 2 (Smythe, De Laup); Shreveport, 1 (Schumpert); Baltimore, 1 (Hall); Memphis, 1 (Burns). The United Kingdom gets 16 cases, with 8 to England, 3 to Scotland, 4 to Ireland and 1 to Wales. Mexico gets 1, Germany 1, India 2, Russia 4, France 2, Australia 2, Italy 1.

Of the nine recoveries reported, counting Burrell's case, covering the first four classes, in which the innominate was actually tied, either alone or with the carotid, vertebral and subclavian, four are to be credited to the

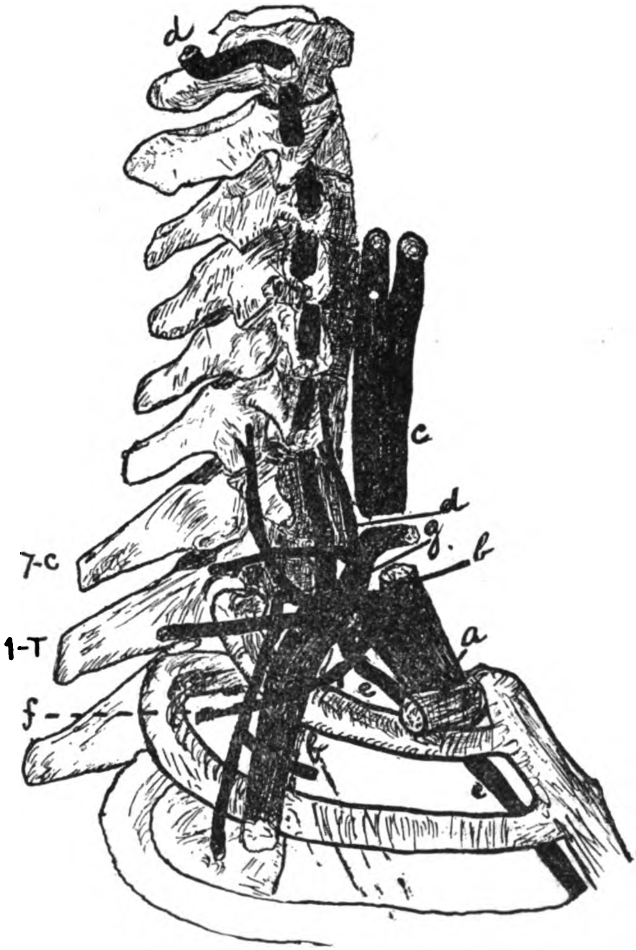

Fig. 1.—Showing relations of the innominate artery; a, innominate artery; b, subclavian artery; c, common carotid artery; d, vertebral artery; e, internal mammary artery; f, transversus scapulæ; g, thyreocervical trunk; 7-c, seventh cervical vertebra; 1-t, first thoracic vertebra.

United States, two to England, one to India, one to Mexico and one to Ireland.

Of cases in the United States, one goes to New York (Curtis), one to Massachusetts (Burrell), one to Louisiana (Smythe), and one to Tennessee (Burns).

Of the attempted ligations (Class 5) one goes to Dublin (Porter, W. H.), one to New York (Hoffman), one to London (Key), one to Rio Janeiro (Peixto), and one to New Orleans (Parham). Of these cases the patients of Porter and Peixto recovered.

Out of the fifty-one times the innominate artery has been approached with the idea of securing it in a ligature, of all the classes 11, or 21.5 per cent., of the patients have recovered. Of the fifty-one cases of all classes, 21 of the patients, or 42 per cent., suffered from wound infection, and 6, or 11.6 per cent., died from shock. Exactly the same number—six—died from some cerebral lesion.

Since the beginning of the antiseptic period, in 27 per cent of the cases the patients have shown wound infection. Wound infection is also shown in 25 per cent. of the patients classed as recoveries of the antiseptic and aseptic periods (since 1871). Out of the eleven recoveries of all classes, 36 per cent. of the patients were infected.

AUTHOR'S CASE.

Patient.—J. H., colored, aged 27, was admitted to the City Hospital, Aug. 6, 1907.

History.—Father living and in good health. Mother died at age of 35 from hemorrhage of the lungs (?). One brother died at the age of 18, cause of death unknown; one sister living, aged 25, in good health. Grandparents all dead. The patient has supernumerary toes and had six fingers on each hand, but the extra ones were removed in infancy. This peculiarity is a family trait. The patient had whooping cough at 3; measles and mumps at 6, and pneumonia at 20, very severely. He had gonorrhea seven years ago, with a bubo, which was lanced five years ago. He had a sore on his penis, also, lasting two months, with "kernels" in the groins and neck. Since that time he had had several attacks

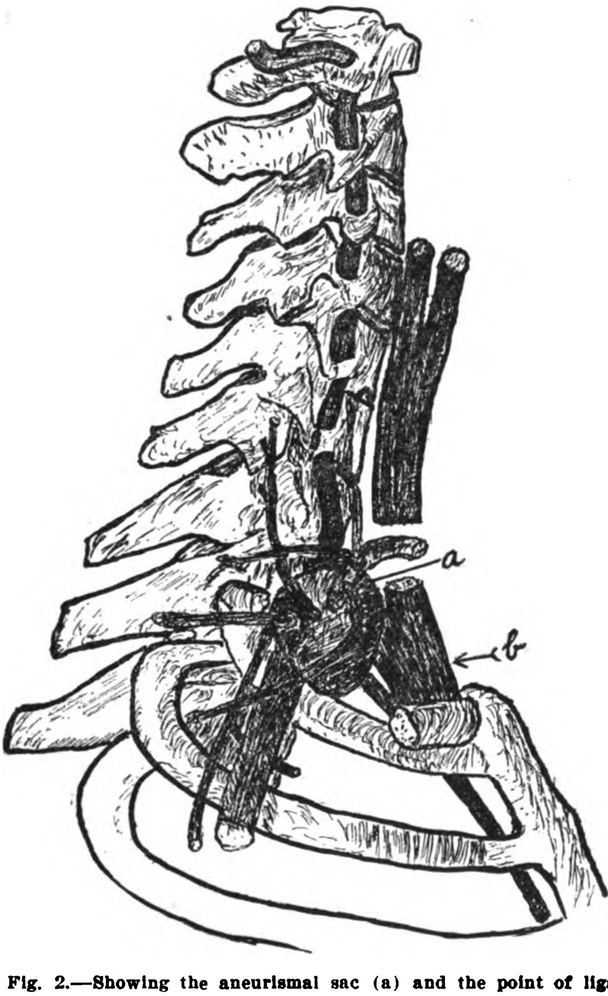

Fig. 2.—Showing the aneurismal sac (a) and the point of ligation (b).

of rheumatism in arms and legs, with some swelling of legs. He had pain and a slight swelling over the breast bone eighteen months ago. Good deal of hoarseness; not much sore-throat. About one year ago he noticed a swelling above the right collar-bone. He painted this with iodin but the swelling continued to grow, and finally, five months ago, the pressure of the growth began to produce pain in the shoulder, both in the supra- and infraspinous regions and down the right arm. For a month, prior to entering the hospital, he had not been able to sleep at night, or to get any satisfactory rest at all, day or night. He worked during the day, because he seemed to suffer less pain when working, than when idle. The arm and hand were edematous and numbness in the hand was complained of.

Operation.—August 9 the patient was operated on. I was assisted in the operation by Dr. Robin Mason. Ether was administered by Dr. Albert Vaughn. The Valentine Mott operation was done. One ligature of the largest size braided silk (pedicle) was tied in a "granny" knot around the innominate artery about one inch proximal to its bifurcation into the common carotid and subclavian. The ligature was drawn just tight enough to approximate the walls of the vessel and not tight enough to crush either of its coats. Pulsation in the aneurism ceased at once and did not return. The patient entered the operating room at 3 p. m., and at 4:20 p. m. he was returned to his bed; pulse 129, respiration 30. At 5:20 p. m. he was very restless, pulse 120; he received codein sulphate gr. ½ and morphin gr. ⅛. At 6 p. m. his pulse was 110. At 8:30 p. m. he was given morphin gr. ¼ and crushed ice. At 10 p. m. patient was sleeping; 10:50 p. m. he was awake and restless and was given morphin gr. ¼. At 11 p. m. he was asleep. At 2 a. m. and 4 a. m. he was given ice water. At 7:30 a. m. patient was asleep.

August 10: At noon his temperature was 100 F., pulse 90; given a light meal at 3 p. m. temperature 100 F., pulse 80. At 6 p. m. he was given a light meal.

August 11: At 3 a. m. his temperature was 99.4 F., pulse 96; rested very well. He reported that he got up during the night to get water. At 9 a. m. the wound was dressed. The swelling (edema) was gone from the hand; numbness was disappearing; pain in shoulder apparently gone. At noon his temperature was 100.6 F., pulse 116. He was put on regular diet. At 3 p. m. his temperature was 99.6 F., pulse 90. The patient had a good night.

August 12: At 9 a. m. his temperature was 100.4 F., pulse 104.

August 13: Patient passed a good night; had one bowel movement. At 9 a. m. his temperature was 100 F., pulse 80; the wound was suppurating and the upper line of incision was broken down. A 1 to 1,000 bichlorid of mercury solution was applied in moist hot pack, at 6:30 p. m. his temperature was 104.4 F., pulse 80. Milk was given. He was restless and complained of his head.

August 14: He had a very good night. At 9 a. m. his temperature was 100 F., pulse 86. The wound was dressed, counter openings made and drainage wicks placed; a hot bichlorid of mercury 1/2000 pack was applied. At 6 p. m. his temperature was 101.4 F., pulse 108. Ate both dinner and supper.

August 15: Patient passed an uncomfortable night. At noon his temperature was 101.6, pulse 96. He was given magnesium sulphate 1 oz. and morphin ¼ gr., codein ½ gr. At 6 p. m. his temperature was 101.6 F., pulse 86. Boric solution was applied on pack. Took both dinner and supper.

August 16: He had a good night. His temperature and pulse were unchanged.

August 17: Patient had a comfortable night; two bowel movements. His temperature was 97.2 F., pulse 98. At 9 a. m. the wound was dressed. At 3 p. m., his temperature was 99 F., pulse 98 F.

August 18: Passed a splendid night. At 9 a. m. the wound was dressed; his temperature was 99.6 F., pulse 80.

August 19: Patient had a very good night. Wound was dressed at 9 a. m.; his temperature was 99 F., pulse 90. At 3 p. m. his temperature was 99.6 F., pulse 72. Had a bowel movement.

August 20: He had a splendid night. At 8:30 a. m. the wound was dressed. At 3 p. m. his temperature was 99.6 F., pulse 108.

August 21: At 9 a. m. the patient's temperature was 97.8 F., pulse 82. At 3 p. m., 99.6 F., pulse 108. He had two bowel movements.

August 22 (fourteenth day): Patient slept well. At 9 a. m. the wound was dressed; at 3 p. m. his temperature was 99.6 F., pulse 104. He had two bowel movements. During the night while he had a normal temperature and pulse he was very uncomfortable. There was hemorrhage from the wound which was controlled with cotton pack and by tightening dressing. He was given morphin ¼ gr.

August 23: At 9 a. m. his temperature was 98.4 F., pulse 96; the wound was dressed. At 3 p. m. his temperature was 101 F., pulse 94; ate three meals.

August 24 (sixteenth day): He complained of pain in head during night. His temperature was 99.4 F., pulse 90. At noon his temperature was 98.4 F., pulse 98; at 3 p. m. 100.2 F., pulse 97. At 3:30 p. m. there was a small hemorrhage from the wound.

August 25.—Patient had slept well. Temperature 100 at 5 a. m. At 9 a. m. temperature was 102.4 F., pulse 108. At 11 a. m. the wound was dressed. At 3 p. m. his temperature was 101.6 F., pulse 98. Patient ate three meals.

August 26: There was a small hemorrhage from the wound at 7 a. m. At 9 a. m. his temperature was 100.2 F., pulse 104. In the afternoon it was the same.

August 27: He had a good night. At 9 a. m. his temperature was 99.8 F., pulse 102; at 3 p. m. 100 F., pulse 101. He had two bowel movements. Up to this date the patient had been getting increasing doses of a saturated solution of potassium of iodid up to 88 drops six times in twenty-four hours; he had now reached the point of iodism.

August 28: Patient's temperature reached normal.

Nothing of consequence occurred until September 30 when the ligature was recovered from the wound while it was being dressed.

DISCUSSION.

ON PAPERS OF DRS. CARREL, GUTHRIE, MATAS AND BURNS.

Dr. J. E. Sweet, Philadelphia: I know of no subject in medicine or biology which has been the direct incentive of more valuable laboratory work than this subject of blood-vessel surgery. The inspiration to research work is like the root of a plant, one root feeding many branches, which spread out in all directions. Beginning with the first work in blood-vessel surgery, the first transfusion in 1657, and following the history of the subject through the years, we come, in the earliest period of the laboratory, to the magnificent work of Landois, the direct result of blood-vessel surgery. the immediate stimulus of all that recent work represented by a new vocabulary of terms, from "agglutinins" to "hormones," and by the new methods of research, from those of hemolysis to that highest development of complex laboratory analysis, the determination of a condition of infection by the method of complement deviation. Work of the kind described to-day, should, I think, be divided in two groups, a group in which the results are immediate—temporary physiologic experiments—and the group comprising the transplantation of organs, vessels and so forth.

I do not agree with the speakers of to-day in thinking that the suture method is the best for the temporary work, for example, the transplantation of the head in order to study

the cerebral functions from the laboratory standpoint. The best method for work of this type is to take a small tube of the diameter of the blood vessel, draw the cut end of the vessel through the tube and turn it back wrong side out over the tube and fasten it with a ligature. The end of the vessel which is to be joined is drawn over this cuff and fastened with a ligature. We then have a tube lined with intima inside and out; the cut edges of the vessel are outside the blood stream; there can be no thrombosis, and the whole process can be performed in less than two minutes. I have in that way transposed the pancreas, the time elapsing from the moment of severing the pancreatic vessels until the blood was again flowing through the vessels, being less than two minutes.

The suture method for permanent transplantations seems to me perfect; nothing can be added to the description we have heard. Several writers on the subject have spoken of the necessity of "perfect asepsis." To my mind there is no such thing as perfect asepsis because any sepsis is perfect asepsis. I object to this term because I find that young surgeons gain from the use of the terms "asepsis," "better asepsis," and "perfect asepsis," the idea that good surgery can be done without asepsis; surgeons must enforce the idea that the word "asepsis" means "without sepsis," is absolute and suffers no qualification, and that aseptic surgery is the only permissible ideal.

Dr. J. F. Binnie, Kansas City, Mo.: Every one is familar with the old demonstration of the circulation in the mesentery of the frog. If, during the examination the mesentery is permitted to become dry, the phenomena of inflammation appears and the circulation soon ceases. If the tissues are kept warm and moist the circulation continues for a long time. This old observation gives the key to success in arterial surgery. The basic law of reconstructive arterial surgery is, "keep the arterial tissues moist and unirritated." Carrel fulfils this law by washing away clots, etc., with salt, or, better, with Ringer's solution, and by appying sterile vaselin to the tissues and to the sutures which he uses. Hertzler in his many experiments on arterial suture failed because he did not keep the tissues moist and prevent his sutures from irritating. An aneurism (apart from a traumatic one) develops only in a diseased vessel and then either at the spot where the disease is greatest or where the strain is greatest. If we can repair this weakened spot so that it becomes as strong as the rest of the vessel (weak though it may be) we have gained much. It is only after cutting into the aneurismal sac that we can judge whether sufficient of the arterial wall, both in quantity and quality, remains to permit an attempt at reconstruction of the vessel. In true fusiform aneurisms reconstruction is manifestly impossible. In some sacciform aneur-

isms, whether with one or two orifices, undoubtedly the vessel may be restored to a good imitation of integrity. If the conditions found after the sac is opened do not warrant an attempt at reconstruction, Matas' obliterative operation should be performed. This operation is usually easy and its great worth has been absolutely proved. In the obliterative operation no attempt should be made to keep the tissues moist by smearing with vaselin. Catgut is the suture material of choice. In the reconstructive operation the law demands that the tissues be kept moist with some substance like vaselin and that the sutures closing the communication between the artery and the sac be of fine vaselinized silk or hemp. After the orifice of communication is closed the rest of the sac may be closed as in the obliterating operation.

Dr. Dean B. Lewis, Chicago: Dr. Burns' case, apparently, was an ideal one for the operation of ligation of the innominate artery for the cure of a subclavian aneurism. In most cases in which the operation has been attempted the aneurismal dilatation involved the innominate artery itself rendering the operation difficult and the remote results uncertain. In 1887 Rosenstirn collected reports of thirty-eight cases in which a simultaneous distal ligation of the common carotid and subclavian arteries had been undertaken for the cure of aneurism involving the innominate artery. Six of these operations were performed before the antiseptic era. Two of the six patients recovered, four died. Thirty-two operations were performed under careful antiseptic and aseptic precautions. Fourteen of these recovered, five were improved, five were not benefited and eight died. Simultaneous distal ligation of the arteries gives a much higher percentage of recoveries than proximal ligation. The term recovery is employed in a relative sense, being applied to those cases in which the symptoms have not recurred for one year and a half and the patient has been able to assume a moderate amount of light work. In many of the cases in which proximal ligation has been performed it has been necessary to perform distal ligation later. It would seem better, therefore, to attempt first distal ligation which is not attended by such a high mortality and to resort later to proximal ligation if the resuls were not satisfactory. In proximal ligation it is necessary to have a free exposure of the sac and this can be secured by dividing sagittally the manubrium down to the lower border of the first rib or sligtly lower and retracting well the divided portions making an incision outward to the border of the first rib.

Dr. J. A. Dana, New Orleans: I have had an experience of seven cases in which I perform the Matas operation, and I will call attention to a few points that struck me. First and most important is the ease and the simplicity of the operation. All that is necessary is to get into the sac after securing hemostasis of the part by constriction of the limb

above, or compression or temporary ligation of the main vessel above; and then to suture the openings that convey blood to and from that sac. Usually the sac has so thinned the overlying structures by stretching and pressure that it is merely a matter of going through the skin and fascia and possibly a few muscular fibers. There has been much misunderstanding in the profession as to the nature of the Matas operation. It means incision of the sac after preliminary arrest of the circulation of the part, and direct suture of the openings within the sac. After doing that, if we find a perfectly clean sac, lined entirely with serous membrane, we close it completely without drainage.

My first two cases were, one femoral and the other popliteal; rupture into the subcutaneous tissues had occurred before I got at them. In such cases one should drain. In the seven cases I had only one really spindle-shaped aneurism. The other six were practically sacciform. Usually the ends of the vessel project into the cavity. The propriety of doing the more complete operation—that is, of preserving the continuity of the artery—is still, I think, a question. In the purely sacciform aneurism, particularly the traumatic, in which there is but one opening in the side of the vessel that leads into the aneurism, one can suture that opening with ease. But where there are two openings some distance apart, the propriety and safety of reconstructing the missing portion of the vessel and maintaining its continuity, becomes a serious question. I have had two cases in which I did this and in one case I think I would have been successful if I had had more experience. Twenty-eight days after I operated I noticed that the aneurism had recurred and when I reopened the sac and dissected the parts loose again I found that four-fifths of the reconstructed vessel was strong and that it had yielded in its lower fifth so that if that portion had been as well sutured and as strong as the rest, I believe that that case would have been successful. In the other case there was a fatal termination and it has taught me never to do the more complete operation unless I can watch my patient for some time afterward. The patient, a negro farm hand, left the hospital during convalescence from a reconstructive operation on an ileofemoral aneurism because he became frightened at the entrance of a supposed case of smallpox, and went to work immediately. He had a recurrence, refused to return for treatment and died from rupture of the aneurism shortly after. If he had remained or returned I would have closed the orifices in a second operation as I did in my previous case. In this case I had to apply a temporary ligature on the common iliac to control hemorrhage.

Dr. D. W. Steiner, Lima, Ohio: Some years ago I made an observation with reference to the clotting of blood, which was just now recalled by Dr. Guthrie's statement he experi-

enced trouble in this regard. With Dr. Sewall in the Physiological Laboratory of the University of Michigan, a study in blood pressure was made. We operated chiefly on dogs and rabbits and experienced great difficulty in keeping the blood from clotting in the canulæ. It was accidentally discovered that with animals that were not fed the day of the observation, there was little clotting and if animals were not fed the day before, there was no clotting even though the study was continued for hours. This would show that in the transfusion of blood a starved animal should be selected.

Dr. George W. Crile, Cleveland, Ohio: I wish to speak of the practical application of the work of Carrel and Guthrie in certain surgical procedures. Among the transfusions we have done, the first was accomplished by anastomosing the radial artery with the median basilic vein. We found the method satisfactory so long as the technic can be carried out, one will not have any difficulty. In a case of cancer of the breast, in order to make a complete excision of the structures involved in the axilla I was obliged to resect about one inch of the axillary artery and made an end-to-end anastomosis according to the method of Carrel and Guthrie. The artery united readily and convalescence was in no way hindered. In a number of instances I have sutured rents in the veins, which were made at the time of operation for removal of large malignant tumors. I have performed the Matas operatwice, once successfully in the case of an aneurism of the femoral artery. A case of aneurism of the abdominal artery was operated on unsuccessfully.

Dr. Alexis Carrel, New York: Surgery of the blood vessels is at its beginning and the question is really almost entirely an open one, at least as far as the application of laboratory experiments to clinical work is concerned. The experiments must be carried out with reference to their practical applications. Suture and transplantation of the blood vessels have been done successfully on animals. In transplantation of blood vessels, however, it is necessary to make a distinction between arteries and veins, and between homoplastic and heteroplastic grafts. After a great many experiments it appears that the transplantation of a fresh piece of artery gives constant, postive results. It is possible that a large aneurism can be extirpated and replaced by a segment of an artery or of a vein. This has been tried in Germany by Lesser, who transplanted a piece of vein after removal of an aneurism. In the applications of the transplantation of vessels or organs to clinical surgery, it would be necessary to modify in some measure the methods which are successful on animals. The anatomic and physiologic conditions of vessels belonging to different species of animals are different. The details of the technic must be exactly adapted to these

differences. To apply indiscriminately to man methods which have been even very successful on animals, would be certainly dangerous.

DR. WILLIAM BRITT BURNS, Memphis, Tenn.: Dr. Lewis spoke of the removal of the sternum. I found that that was done in one instance. Resection of the clavicle was done in four cases, but usually the bifurcation of the innominate is high enough up to be reached by the Valentin Mott incision with the head thrown back and arm down. The patient I presented had hemorrhages on the fourteenth, sixteenth, and seventeenth days. The wound suppurated, probably because of the very hot weather, the perspiration running down his face and chin into the dressing, which, I think, he displaced by pulling. The ligature was recovered on the twenty-first day. The collateral circulation is through the subscapular and the aortic intercostals.

DR. RUDOLPH MATAS, New Orleans: Catgut if used in the crude state would be a defective material for use in vascular surgery. Ordinary catgut sterilized by heat would never do, but hardened chromic gut does very well, as we have proved in all cases in which it has been used. In obstructive and obliterative cases we should adopt the principles of Carrel's technic, but in all obliterative cases we would use chromic gut, No. 1, for closure of the opening and obliteration of the sac.

ARTIFICIAL RESPIRATION IN ITS PHYSIOLOGIC ASPECTS.

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In order to estimate the value of any method of artificial respiration it is necessary to bear in mind certain general principles and to determine with some approach to accuracy certain statistics.

The most important of the principles concerned is the elasticity of the lungs and thorax, by virtue of which alterations in volume caused by distortion of shape under the influence of an external force are followed, on removal of the distorting force, by a return to the original volume. It is by virtue of this principle that expiration is ordinarily effected, the distorting force usually acting so as to increase the capacity of the thorax by raising the ribs and depressing the diaphragm; on its removal these parts return to their original position. But, artificially, the distorting force can be made to act in an opposite manner, viz., by diminishing the capacity of the thorax and thereby forcing air out of the lungs; on now removing the distorting force the elasticity of the thoracic wall causes air to pass into the lungs and inspiration becomes produced.

The possibility of effecting artificial respiration in this reversed manner, using pressure as the active agent to cause expiration and the elasticity of the thoracic wall to produce inspiration, was demonstrated by Dr. B. Howard of New York, who in 1868 published an account of a method of performing artificial respiration

which has since been largely used by physicians and surgeons in threatened death from asphyxia or from administration of anesthetics; this method was introduced by Dr. Howard for employment in cases of drowning. The method consists in laying the patient on his back, kneeling over the lower part of the body, and alternately pressing on the lower part of the chest and relaxing the pressure, repeating the operation eight to ten times a minute. The advantage of the method is that it is simple and that the patient on the operating table is usually in the supine position. The disadvantages are: that the tongue is apt to fall backward and block the pharynx, therefore, needing to be drawn forward; that the ribs in senile subjects are brittle and may be fractured; and that the liver in asphyxia is congested and greatly enlarged and is liable to be ruptured; this is especially the case in drowned subjects.

Another common method of performing artificial respiration—that suggested by Silvester—appears at first sight to be more truly physiologic, since it attempts to imitate natural respiration by raising the ribs and thus increasing the capacity of the thorax. This is effected by forcibly drawing the arms upward toward the head; the muscles passing from the arms to the chest wall, which are attached to the ribs, are thus made to drag the ribs upward. Expiration is effected by lowering the arms and pressing them against the sides of the thorax. At least three persons are needed to operate by this method, one to activate the arms, another to hold the tongue out from the mouth—for the patient is in the supine position—and a third to hold down the trunk and prevent its being bodily moved. Silvester's method was described by him in 1858.

Marshall Hall's method, which was published in 1857, consists in rolling the patient alternately from the lateral to the prone position and pressing on the back between the shoulder blades when in the latter position. Its efficacy was supposed by Marshall Hall to depend on

the change of posture, which, by altering the pressure on the chest in the successive positions of the body, alters its capacity; he accordingly termed it the postural method. It has the advantage over the other two methods that the tongue does not require to be drawn out of the mouth by a special operator, and that, in cases of drowning, water and mucus tend naturally to flow out and do not accumulate at the back of the throat, as is the case when the patient is in the supine position.

In 1890 the Royal Medical and Chirurgical Society of London appointed a committee to investigate the efficacy of these and other methods of performing artificial respiration, and of this committee I was made chairman. A large number of experiments were performed on the cadaver, which were mostly futile by reason of the difficulties presented by postmortem rigidity. Subsequently transferring the work to Edinburgh, we made similar investigations on the living passive subject, and also investigated in dogs both the physiologic phenomena presented in drowning and the best means of producing recovery in these animals by artificial respiration. In this research I received the aid of Dr. P. T. Herring of the physiology department of the University of Edinburgh and of my other assistants there.

As the outcome of this work we concluded that, for the performance of artificial respiration without the aid of bellows or other apparatus, a pressure method is best, and that such a method is most efficient with the patient in the prone position and with the pressure applied vertically over the lowest ribs. In this way not only is the thorax compressed, but also the abdomen, against the ground. The pressure on the abdomen forces the viscera against the diaphragm, which is thereby itself moved upward, driving air out of the lungs. On relaxing the pressure the elasticity of the parts causes them to resume their former shape and volume, and air is drawn in through the glottis. The pressure is exerted gradually and slowly, occupying some

Fig. 1.—First position of operator and patient for effecting artificial respiration by the "prone pressure method" described by Professor Schäfer. The operator's hands are over the lowest ribs of the patient.

Fig. 2.—Second position of operator, who is throwing his weight vertically on his wrists, thus putting pressure on the thorax and abdomen of the patient. This pressure is exerted slowly, occupying some three seconds and is then removed for a period of two seconds and again applied.

three seconds; it is then removed during two seconds and again applied; and so on some twelve times a minute. To this method I have given the name of the "prone pressure method." The method is illustrated by the appended cut (Figs. 1 and 2), which are from photographs taken for the Royal Life Saving Society.

In performing it the operator kneels or squats by the side of or across the patient, places his hands over the lowest ribs and swings his body forward and backward so as to allow his weight alternately to fall vertically on the wrists and to be removed; in this way hardly any muscular exertion is required. The efficiency of a pressure method of artificial respiration depends on the fact that after an ordinary expiration the thorax still contains some 1,500 c.c. of air which can be expelled by a forced expiratory effort; this is the reserve or supplementary air of Hutchinson. It is easy to conceive that one-third of this reserve air, i. e., 500 c.c., can be forced out from the chest by pressure, and, as a matter of fact, considerably more than that amount can be expelled when the pressure is applied in the prone position as just described. By repeating the movements—pressure and relaxation—twelve times a minute, we easily get an air exchange of 6,000 c.c., which is more than the average normal amount.

It is somewhat curious to find that up to the time of our investigations no one seems to have tested the efficacy of the current methods of performing artificial respiration by determining the quantity of air per minute which can be pumped into and out of the lungs. Attempts had been made on the cadaver to test the effect of single inspiratory or expiratory movements, but these all proved of little value, for the reason already given. In any case it is of first importance to know what would be the result of keeping up the efforts of artificial respiration during a given time at the normal rate. To this matter we accordingly directed our atten-

tion. To measure the amount of air delivered per minute by the several methods above described we employed a spirometer with counterpoise devised by Marcet, so arranged that when the inner cylinder is raised from the water in the outer cylinder its increasing weight is *pari passu* counterbalanced. A mask was fitted over the mouth and nostrils of the subject (or a mouthpiece was used, the nostrils being closed) and a double set of water valves was so arranged in connection with the mask that the air could pass through one valve into the mask and air passages during inspiration and through the other valve into the spirometer during expiration. In this way not only can the amount of air pumped into and out of the chest in a single respiratory movement be measured, but, what is of more importance, the amount which is pumped in and out in a given time—say, one minute or five minutes.

It is known from the experiments of Vierordt that the average amount of air which a man breathes in and out of the lungs per minute is between 5,000 c.c. and 6,000 c.c. If the rate of respiration is twelve per minute, this will give a tidal air volume of nearly 500 c.c. Any method of artificial respiration which fails to provide for an air exchange of less than 5,000 c.c. per minute is therefore less efficient than normal, and a marked deficiency of air exchange should lead us to reject such method. The importance of subjecting all proposed methods of artificial respiration to this test is obvious.

The following figures represent the results of one of a series of comparative experiments made to test the efficacy of the Silvester, Howard, Marshall Hall, and prone pressure methods as compared with natural respiration. Both the subject and operator were the same throughout. In the first place the amount yielded by natural respiration was determined. The rate of respiration was thirteen per minute; the amount of air exchange per minute was 5,850 c.c.; the amount of tidal air works out therefore to 450 c.c. Pumping by the

Silvester method at the rate of the natural respiration of the same individual, the amount of air exchange per minute was 2,280 c.c., giving a tidal air amount of only 175 c.c., which we recognize as quite inadequate.

With the Marshall Hall method the results are similar; an exchange per minute of 3,300 c.c. is registered, giving a tidal air volume of 254 c.c.; also inadequate. With the Howard method the results approach more nearly to the normal; the exchange per minute is 4,030 c.c. and the tidal air volume is therefore 310 c.c., i. e., some two-thirds of what was determined to be the natural amount of exchange in the individual who was the subject of the experiment. On the other hand, by the prone pressure method the amount pumped through the lungs per minute was 6,760 c.c., giving a tidal air volume of 520 c.c. That is to say, this method proves to be completely efficacious and capable of effecting an air exchange greater than that produced in normal respiration.[1]

In cases of drowning there can be no question that the prone pressure method of artificial respiration is always indicated. Its advantages are: 1, That it is fully efficient; 2, that it can be performed without fatigue by a single individual; 3, that it is simple and easily learned; 4, that it allows the tongue to fall forward and the mucus and water to escape from the mouth so that the tendency of these to block the passage of air, which is inherent to the supine position, is altogether obviated. It can be applied equally well in attempting to revive a patient whose respiration has ceased in consequence of an overdose of chloroform or other anesthetic. One of the difficulties and dangers of a general anesthetic is the excessive secretion of saliva and mucus. This, with the subject in the prone position, would tend to flow out of the mouth. With chloroform another

1. The efficacy of the prone pressure method was demonstrated to the Section by measuring the amount of air which could be exchanged in a given time as compared with that exchanged by natural respiration.

source of danger is the tendency of the heart to undergo fatal inhibition, owing to the influence of the drug on the vagus center. Both these dangers are obviated by the hypodermic administration, prior to the operation, of a small dose (1/50 grain) of atropin sulphate. It seems strange that anesthetists do not generally adopt this simple precaution as a routine method. They would thereby be saved much anxiety, and the paragraphs in the newspapers headed "Death During Administration of an Anesthetic" would be much more rare than they are at present.

I have spoken hitherto of methods of artificial respiration which do not require the use of apparatus. Such methods are the only ones which are usually available in cases of drowning, and of these the prone pressure method is certainly as efficacious as any method which involves apparatus. Circumstances, however, may and do arise in surgery in which artificial respiration is called for but which would not permit of the employment either of this or of the other methods above described. In these cases the simplest apparatus which can be employed is an ordinary bellows or a piston cylinder. It is not even necessary to introduce the air directly into the trachea, for, as Horvath observed, if the nozzle of a bellows is introduced into one nostril, the other nostril being left open but the mouth kept shut, it is possible by a vigorous movement of the bellows to distend the lungs quite efficiently, and, by repeating the movement regularly, to carry on artificial respiration. In dogs I have repeatedly obtained recovery after drowning by the employment of this method, in spite of the much greater intricacy and narrowness of the nasal passages in these animals. But in surgical operations which involve the opening of both sides of the chest it would be safer to perform intubation of the larynx, or even temporary tracheotomy. In any case it is highly desirable in such circumstances to adopt, if possible, the prone position for the patient. Under some circum-

stances a tendency to dyspnea is increased by the supine position. This is the case in dogs with artificial pneumothorax and appears to depend on the position assumed by the heart. Dr. Elsberg recently showed me, at the Rockefeller Institute in New York, an experiment which illustrates this in a striking manner. An animal with a single pneumothorax, which was highly dyspneic when on its back, passed into natural and quiet respiration as soon as it was turned over onto its belly.

Whether for certain surgical procedures it is necessary to carry on artificial respiration by enclosing the body of the patient along with the operators in a chamber within which the air is rarified, it is no part of my function in opening this symposium to consider. We shall doubtless be made acquainted by Professor Sauerbruch with his reasons for adopting this relatively complex method in preference to the simpler positive pressure method which is adopted in physiologic laboratories for similar operations. But there must obviously be a sufficient air exchange whether this be furnished by rhythmic fluctuations in the air pressure of the chamber, permitting the lungs to draw in or drive out air from their cavities, or by a steady stream of air or oxygen passed into and out of the air passages. If this exchange is carried out there is no reason why a method in which respiration depends on the production of expansion of the lung by negative pressure outside it should not be as efficacious as one which depends on positive pressure applied through the air passages. The principle is, in fact, really the same in both cases and in the Sauerbruch chamber, as in natural respiration, it is actually the positive pressure of the atmosphere which produces the lung expansion; the difference between the two methods being that, in the one, pressure on the inside of the alveoli is increased by the action of the bellows, while in the other the pressure on the outside of the alveoli is decreased by the action of the exhaust pump.

PRESENT STATUS OF SURGERY OF THE THORAX

AND THE VALUE OF THE SAUERBRUCH NEGATIVE PRESSURE PROCEDURE IN THE PREVENTION OF PNEUMOTHORAX.

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When I was accorded the honor of an invitation to deliver an address before the Section on Surgery and Anatomy, of the American Medical Association, it occurred to me that it would be a suitable opportunity to present the modern methods employed for opening the thoracic cavity and to give you the results of many personal experiences obtained during the past four years in the use of my pneumatic cabinet. The inefficiency of the methods in vogue up to that time prompted me at the solicitation of my then chief, von Mikulicz, to endeavor to devise a method of operation which would obviate the dangers incident to thoracic surgery. I began by analyzing the methods used to prevent the occurrence of pneumothorax, especially the method of artificial respiration which had been used extensively and successfully in animal experiments for more than a hundred years, and, more recently, in an improved manner, by Matas and several others in the human being. I soon became convinced that this method possessed too many disadvantages ever to become practical. That led me to experiment with negative pressure, basing my work on the known prin-

ciples of the difference between the intrabronchial pressure and the pressure at the surface of the pleura, about 7 to 8 mm. Hg, which serves to keep the lungs distended. If the normal relationship between these pressures is disturbed, as by opening the thorax, the lungs collapse and the result is a pneumothorax, which may be followed by serious disturbances, such as dyspnea, displacement of the diaphragm and heart, vagus reflexes, etc. Believing that these complications would not occur if the normal relationship of these pressures could be maintained, I was led to carry out the following experiments: The ends of a glass cylinder were sealed with gutta percha paper. One end was perforated by three openings, two small ones, and one large one; the opposite end was perforated by a single large opening. The animal was placed in the cylinder, so that the head protruded from one of the large openings, and the legs and lower part of the body through the other opening. I passed my hands in through the small openings, endeavoring to keep the cylinder airtight. Next, the cylinder was exhausted sufficiently to reduce the air pressure 10 mm. Hg; then I opened the thorax—and the lungs did not collapse, nor was the respiration disturbed in any way. This primitive apparatus was replaced by a better and a larger one, and then by a small operating room, in which I performed a number of intrathoracic operations, such as resection of the lung and esophagus and operations on the heart, and always with the same result, total absence of pneumothorax.

The result of these experiments was the building of an operating room for practical use. The first operation done in it (resection of esophagus) proved positively that the results obtained in animal experimentation could be duplicated in the case of the human being—that pneumothorax could be prevented.

Soon afterward Brauer published results obtained with a modification of my procedure, the so-called plus

or positive pressure, which has not as wide a range of applicability as has my method, although the improvements that have been made in the apparatus used by Brauer have also increased the advantages of the method.

Having established the correctness of the principle of my method, it became necessary to elaborate the operative technic, by no means a small task. Von Mikulicz, Kuettner, Meyer, Tiegel, Seidel, and Freidrich participated in this work, and the result has been eminently satisfactory. Definite rules have been laid down for certain operations, which I will endeavor to explain to you. So far as the anesthetic is concerned, it is remarkable how small a quantity is necessary to produce complete anesthesia, and then only at the time of opening and closing the thoracic cavity. During the remaining steps of the operation very little of the anesthetic is required. It has been shown that it is unwise to reduce the pressure more than 7 to 8 mm. Hg, and Friedrich has had excellent results with a negative pressure of 3 to 5 mm.; in fact, such a minimum reduction should always be employed during intrathoracic operations, as on the esophagus or lungs. or when it becomes necessary to expose the mediastinum. Before concluding the operation, however, it is essential to raise the pressure to 7 or 8 mm. Hg, so that the lungs may become fully expanded, filling the chest cavity completely. Needless to say, the strictest asepsis must be observed, as in abdominal operations, and complete hemostasis is of the greatest importance, especially when entering the thoracic cavity, so that as little blood as possible will enter.

As to the indications for this method: It was particularly desirable to employ it in the removal of large tumors of the chest wall. Numerous attempts have been made to remove such tumors, especially sarcomata of the ribs, involving the lungs and pleura. Previously, tamponade and drawing the lungs forward into the wound were resorted to, in order to prevent the occur-

rence of pneumothorax; and, while these measures proved successful in some cases, they are not entirely satisfactory, and serious complications, even death, following these procedures are not unknown.

The first case operated on in the pneumatic cabinet under negative pressure was one of sarcoma of the ribs. No disturbance whatever followed the extensive opening of the thorax; the field of operation was exposed freely, showing the advantages of the procedure in cases where such extensive resection of the chest wall is necessary. Soon afterward I had an opportunity to operate in a case of extensive mammary carcinoma involving the chest wall. The case was considered inoperable, because several ribs and much of the soft parts would have to be removed to give even a reasonable hope of securing some slight measure of success. The defect caused by the removal of the tumor was so great as to necessitate a plastic operation. In accordance with the usual procedure in such cases, I transplanted the healthy breast to the site of the one that had been removed, placing it directly over the lung, which filled in the defect very nicely. The flaps were sutured to the surrounding soft tissues by means of a two-tier suture. The result was a complete success. The operation was repeated, with equal success, in a number of other instances, and similar results were obtained by Haecker and Kuettner, at the Breslau Clinic.

Practical experience in ten cases has shown that the dangers of these operations, especially from involvement of the pleura, are lessened greatly, and that the contraindications for the employment of more radical procedures are fewer than before; involvement of the ribs and pleura in mammary carcinoma is no longer a contraindication for operation. It is also possible to operate more extensively and with better results in pulmonary emphysema and tuberculosis, and in performing cardiolysis, although every effort will be made now as before to avoid injury of the pleura. If, how-

ever, in spite of care observed, the pleura is injured, my apparatus will absolutely prevent the occurrence of pneumothorax. The possibilities of the method in lung surgery, especially in the surgical treatment of pulmonary tuberculosis, will constantly become greater, but a final opinion must be withheld for the present and we must not expect too much; in fact, I believe that in such cases thoracoplastic operations or the artificial pneumothorax will yield better results.

Before proceeding to discuss the use of my method in the treatment of diseases of the lungs in general, I wish to speak more particularly of its use in the treatment of empyema, where my results have been excellent. It is important not to be content with the lessening of the size of the opening in the pleura through expansion of the lungs; the operation must be performed under differential pressure. The expansion of the lung forces out the exudate that may be present, and prevents the occurrence of pneumothorax, while shrinkage of the lung, with subsequent scar formation, is lessened considerably. All recent empyemas and a considerable percentage of the chronic ones yield quickly without the formation of a fistula; the patient is spared tedious after-treatment and subsequent plastic procedures.

The operation is performed in the usual manner, with a negative pressure of 7 mm. After evacuation of the pus a gauze dressing is applied without drainage, and a mammoth dressing is put on over all, thus preventing the entrance of air into the pleural cavity. The dressings remains in place until the fifth day, when it is removed and a new one applied in the pneumatic cabinet. The lung is now adherent to the edges of the wound, and the subsequent treatment is that for an infected granulating wound.

The diseases of the lung in which surgical treatment is particularly indicated and successful are gangrene and abscess; in fact, it is in the treatment of these conditions that lung surgery had its inception. When

the disease is superficial, the treatment is simpler, and pneumothorax need not be feared. The treatment is the same as for the same conditions elsewhere in the body. It is only when the lesion is central that the operation is of magnitude. An operation performed under negative pressure possesses several advantages. Aside from the fact that the possibility of pneumothorax is obviated, the anatomic relationship of the parts is more apparent, because of the expansion of the lungs. The diseased portion of the lung is brought into view and the lung is sutured to the edges of the wound. The abscess is opened by means of the galvanocautery. It is here that my method is especially advantageous in that it prevents the aspiration of foreign material into the healthy parts of the lung. The excess pressure in the bronchi prevents gravitation of fluids and forces every particle of free blood to the wound surface, where air-bubbles are seen to burst, driving before them particles of blood and pus. Experiments on animals have proved the correctness of these statements. Even when a large blood vessel has been severed, one which empties itself directly into the lumen of the bronchus, aspiration does not take place. The blood is forced out by the excess pressure.

This fact is also of the greatest importance in the after-treatment, and experience has shown that changes of dressings, at least at the beginning, should be made under differential pressure, not because of pneumothorax, but solely because it tends to remove blood and pus from the bronchi.

As to the bronchiectases: Here we must distinguish between the varieties of this affection. When the lesions are multiple, operative intervention, with the hope of a radical cure, is out of the question, and the same is true of the tuberculous bronchiectases, even when only one lung is involved. Thoracoplasty, with extensive resection of ribs and mobilization of the chest wall, is preferable to intrapleural treatment. At present

an operation is indicated in bronchiectasis only when the lesion is isolated in one lobe of the lung. This lobe must be resected.

Two years ago I saw a case of this kind, occurring in a girl 22 years old. The lesion was circumscribed and confined to the lower lobe of the lung. The operation was done under negative pressure. The whole lower lobe was of a deep, dark, bluish-red color, contrasting clearly with the grayish-red color of the remainder of the lung. The diseased portion of lung was of a firm consistency, hard and airless. In these cases the best procedure is resection of an entire lobe, as in the case of tumors.

Primary carcinoma of the lung is exceedingly rare. Only once have I resected a considerable portion of the lung for this affection. The case was a very interesting one. A woman 34 years old had severe pains of about three months' duration in the left side. The pain was radiating in character, paroxysmal, resembling a typical intercostal neuralgia. Pressure on the nerves promptly induced a paroxysm of pain. Inasmuch as the examination failed to disclose any pathologic condition, the patient was treated with the usual remedies, but without securing relief. She was sent to the clinic for nervous diseases at Greifswald, where a diagnosis of intercostal neuralgia was made. At her discharge her condition was the same as before.

She then was referred to the surgical clinic. Her physician informed us that there was a circumscribed area of dulness in her left side, which did not convey the impression of either an exudate or of pneumonia. He suggested a malignant growth. The examination confirmed these findings, and we further succeeded in making an absolute diagnosis of carcinoma of the lung because of the finding of nests of carcinoma cells in the sputum. Failing to find a similar tumor elsewhere in the body, we concluded that this was a case of primary carcinoma of the lung.

An incision, 30 cm. long, was made in the left fourth intercostal space. There were no adhesions between the pleuræ. The tumor involved the left lower lobe, except at its most dependent portion, and in two places extended into the upper lobe. The surface of the tumor was nodular. Two of these nodules, about the size of a small apple, situated in the parietal pleura under the fifth rib, pressed on the intercostal nerve, thus explaining the intercostal neuralgia. At this particular spot the tissues had grown together and there was also some necrosis of the ribs, the result of pressure. I resected extensively the third, fourth and fifth ribs and the attached soft tissues, so as to secure free access to the lung. I was successful in isolating the diseased tissue, but was unable to extirpate because the pleura was firmly adherent to the pericardium and the diaphragm. Only the top of the tumor was removed.

The patient recovered quickly from the operation and was discharged after four weeks. Three months afterward she was still free from pain, but was rather weak.

Operative intervention in bronchiectasis and tumors of the lung should, if possible, consist in amputation of an entire lobe of the lung. Occasional attempts have been made to do this, but the procedure has been discouraged. The main difficulty in such resections is caring for the bronchus afterwards. On it depends the success of the operation. It is rather difficult to suture a bronchus, and if the sutures loosen, air will enter into the mediastinal tissues, producing mediastinal emphysema, a serious complication. Various operators, have called attention to this fact, especially Garrè, Talke, Tiegel and Friedrich. According to the latter, the technic of the operation is as follows: After exposing the bronchus at the hilus, and, if possible, freeing the vessels from it, it is clamped loosely with forceps protected by rubber tubing. The forceps were passed in from before backward. The

bronchial mucous membrane is curetted away with a small sharp curette. Three cm. above the opening of the bronchus in the diseased area a ligature is passed around the tube and tied tightly. The proximal clamp is then removed. The lumen of the bronchus will eventually be closed by granulation tissue. If necessary, a second ligature—one of catgut—may be applied proximal to the main ligature, so as to act as a dam to lessen the tension on the main ligature that might be caused by attacks of coughing. The principal ligature, of fairly heavy silk, must be tied securely. The wound in the lung must be easily accessible. The dressings must be changed in the pneumatic cabinet, because in that way only can pneumothorax be prevented. I have seen this accident occur once because this precaution was not taken. The patient died from a suppurative pleurisy. The immediate danger of pneumothorax, while serious, is not to be feared as much as the infection which may occur.

It was to be expected that, as soon as it was possible to obviate the occurrence of operative pneumothorax, surgeons would view the treatment of intrapleural injuries differently. Many surgeons, particularly Tuffier and Garrè, recommended care in the treatment of injuries of the lung, particularly when there was much hemorrhage. The principal reason for this caution was the fear of pneumothorax and infection. Nevertheless, operative procedures proved successful in many cases of lung injury (Garrè, Tuffier, Grunnet, etc.). I have operated under negative pressure twice for rupture of the lung, and Kuettner performed suture of the lung hilus successfully in two severe cases of injury. He operated solely to check hemorrhage. In my cases the lung was ruptured or torn by fragments of the rib causing a tension pneumothorax. Both patients were highly dyspneic when they came to operation and there was extensive emphysema of the skin in both cases. It was in these cases that I was particularly impressed

with the disastrous results following pneumothorax and emphysema of the diaphragm caused by displacement of the heart and the healthy lung. But above all was I impressed with the inefficiency of the previous methods of treatment and the particularly happy results that were to be obtained from operating under negative pressure. As soon as the skin incision was made, I noted that the air contained in the tissues was pouring out into the pneumatic cabinet and very soon all evidence of emphysema had disappeared. When the thoracic cavity was opened, the collapsed lung was seen to be resting on the distended mediastinum, but while we were watching, it began to expand and at the same time the mediastinal emphysema gradually disappeared. The two layers of the pleura again were in contact and the heart action became normal after the air pressure was removed. These observations led me to examine into the clinical history of tension pneumothorax more closely; but of this I will speak at another time.

I wish to mention in this connection that, when operating under negative pressure in these cases of lung injuries, the injured area is easily located. The air is seen to pass out from it in the form of blood-red foam; or the hand may feel the air current as it passes out from the injured area. Of the various methods employed for suturing the lung tissue, I prefer those of Tiegel and Friedrich. It is important to bring the serous surfaces in apposition, as in intestinal suturing. Whether drainage should be employed is a question that I would answer in the negative. My experience has been that it is preferable to close the wound immediately, unless the operation is performed some time after the occurrence of the injury and when infection is present in the pleural cavity.

My method of operating under negative pressure is indicated particularly in operations on the thoracic portion of the esophagus. Heretofore, this has always been a great problem. After many trials and tribulations

and much experimental work on animals (in which I had the guidance of von Mikulicz), I succeeded in developing a technic which made it possible, at least in the case of animals, to resect successfully large portions of the esophagus. The essential feature of the method is the avoidance of sutures and the use of the Murphy button to secure anastomosis. Operations which may be and have been employed successfully on human beings are gastro-esophageal anastomoses and resection of the cardia. I have on previous occasions described this operation and have employed it in nine cases. All of the patients died. Similar results were obtained by Tuffier in three cases, Kuettner in two cases, and Wendel in one case of carcinoma of the esophagus. It may seem venturesome for me still to believe in the possibility of resection of the thoracic portion of the esophagus, and yet the repeated observation that the tumor was too large or that it was operated on when already far advanced, or the belief that the technic was at fault, led me to conclude that in favorable cases the operation must prove successful.

A case that pursued the most satisfactory course of any of the esophagus resections was one in which an operation was done last year. A woman 45 years old had a carcinoma of the esophagus about ten cm. in diameter, the upper end extending slightly above the left bronchus. In spite of its position, it was possible to isolate the tumor and not injure the vessels and nerves. I resected that portion of the esophagus, but unfortunately I could not bring the ends together. The upper end was switched off sideways. The patient died on the fifth day from pleurisy and pericarditis. However, the operation itself was technically successful, and I believe will prove entirely successful in suitable cases. The most favorable cases are of carcinoma of the cardia. An examination of twelve thousand dissected cases has shown that this class of tumor is relatively frequent, metastases late, and does not spread rapidly locally.

Our operative results thus far have shown that these tumors should be attacked through the thorax and not through the abdomen. If the tumors are small, the end of the esophagus is invaginated into the stomach, and at a second operation the tumor is excised through the stomach. In the case of larger tumors, the tumor is resected and an anastomosis is done between the stomach and esophagus. It is advisable to make this a lateral anastomosis, using the Murphy button, passing the male portion of the button into the esophagus through the mouth by means of a long sound.

The thoracic cavity is opened in this operation in the fifth interspace, with or without resection of the ribs. In order to expose the field of operation as much as possible, the incision is kept open by means of Mikulicz's rib clamp or retractor. The negative pressure during the operation ought not to be higher than three to five mm., being raised to seven or eight mm. toward the end of the operation. After having sutured the periosteum, the skin and fascia are closed by means of tier sutures.

On basis of extensive studies and one experience on the living subject, I have come to the conclusion that in cases of deep-seated carcinoma of the cardia, i. e. cases in which the upper border lies below the diaphragmatic slit, resection of the costal arch, as recommended by Dr. Willy Meyer, of New York, for this purpose four years ago, is a procedure of great practical value.

Surgery of the heart has been advanced the least by this new procedure. The reason for this is that injuries to the heart always occur accidentally and any treatment is done in an emergency. A series of operations on the heart has shown that it is possible to expose the heart freely without opening the pleural cavity, and that the patient usually recovers from pneumothorax when this occurs. But it is probable that surgery of the heart will profit and be advanced by this new method. A year ago I proved experimentally that the

use of negative pressure was advantageous in many ways, which I can not mention specifically at this time.

I can not close my remarks on this subject without referring briefly to exploratory thoracotomy. I believe that this is justifiable more often than is thought, because of our shortcomings in the diagnosis of diseases of the thoracic cavity. The same is true of the thorax as of the abdomen; an exploratory laparotomy or an exploratory thoracotomy will often clear up a doubtful case. This is particularly true in the case of foreign bodies in the lung, when the Roentgen ray fails to make the diagnosis. The operability of esophageal carcinoma may also be determined by thoracotomy when both the Roentgen ray and esophagoscopy have failed. Of course, the incision should not be a large one, and rib resection should not be resorted to. If done quickly and cautiously, the incision is free from danger and will prove valuable in many cases. Only in this way can we hope to make haste slowly.

ARTIFICIAL INTRAPULMONARY POSITIVE PRESSURE.

EXPERIMENTAL APPLICATIONS IN SURGERY OF THE LUNGS.

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The ingenuity of Professor Sauerbruch in conceiving the use of negative pressure to prevent collapse of the lung and in constructing his cabinet can not be denied. The size and cost of such an apparatus, however, together with its lack of portability, justifies, I think, investigation and experimentation to obviate the difficulties which have been associated with the use of positive pressure. For we must admit that some simple inexpensive positive pressure device would be more practicable for general use.

My investigations have been exclusively in animal experimentation under the positive pressure method. The objects have been, first, to apply a practical surgical test in animals; second, to refute if possible certain well-known objections to the method; and, third, to improve the application of air compression in order better to maintain ventilation of the lungs and consequent oxygenation of the blood.

The method which I have employed is not the rhythmical inflation method but the use of a steady air compression by the method of Brauer. I first performed thirty thoracic operations on dogs. Wide opening of the right chest was established in all of these cases for periods varying from two to four hours. The air compression

was introduced through the apparatus shown in the lantern slides (Figs. 1 and 2). A simple glass face mask was used. Several simple thoracotomies were done with wide openings, and the remainder of the operations consisted in the removal of greater or less portions of the right lung. Of nine deaths in these thirty cases sepsis and the incomplete closure of the lung stump or thorax opening were the chief causes of death. None of the fatalities could justly be attributed to the use of positive pressure. The animals withstood the administration of compressed air without manifesting unfavorable symptoms during the operation, and in the two months' convalescence of the recovered cases no symptoms developed which could be attributed to the use of air compression.

Dr. Sauerbruch, in a paper of 1904, raised as an objection to my method the fear of "interstitial emphysema as a result of the artificial inpumping of air." But here I would emphasize that under regulated introduction of compressed air the sudden blowing up of the collapsed alveoli, such as occurs in rhythmical inflation, is not an existing danger. The air compression must be regarded as a constant factor. Its passage in and out of the lungs should be obstructed only enough to maintain the lung in a state of inflation a trifle below that which is normal to it. If then the lung is never allowed to become collapsed and then suddenly blown up, and if the outer surface of the lung is never hyperinflated beyond the level of the inner thoracic wall, we have no reason to expect a rupture of the alveoli. In fact interstitial emphysema was not found present in any one of the fatalities or recoveries in this series of thirty operations.

We have been told that in the use of positive pressure dangerous changes in the circulation must occur. This objection led me to perform twenty-five blood-pressure experiments. Dogs exclusively were used. Ether anesthesia was employed without previous morphin injec-

Fig. 1.—During the removal of a positive pressure apparatus from the face, head, or pharynx, in case of vomiting or ether spasm, the application of a thorax cup as shown converts an open pneumothorax into a closed one and the normal physiologic conditions are more nearly maintained. This cup should be applied at the end of expiration, and thus at inspiration a partial negative intrathoracic pressure is produced. No suction need be applied to cup.

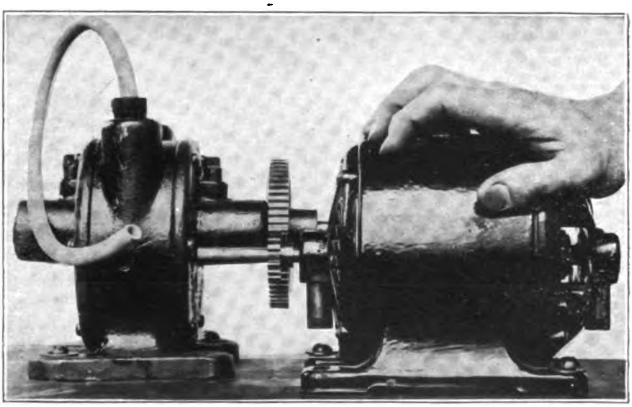

Fig. 2.—This rotary air pump run by a 1/6 horse-power motor supplies a steady air compression with ample cubical volume of afferent air. Its work can be regulated by adjusting the speed of the motor. The use of tanks is thus avoided and it is in other respects preferable to any of the forms of hand or motor bicycle pumps. Its portability is of advantage.

tion. In twenty of these experiments aortic pressure was recorded from the left carotid. One or both chests were held wide open with rib-spreaders, and in five cases the entire front of the thorax was removed. The air compression was carefully regulated and all exciting traumatic nerve stimulation, such as traction on the lung or undue irritation of the pleura, was avoided as far as possible.

The aortic pressure in these experiments maintained a normal level and the heart action was not disturbed. But inasmuch as changes in the pulmonary circulation might be present and not manifest in the aortic tracing, the pulmonary pressure was also recorded in ten experiments. In six of these the right ventricular pressure was obtained through a glass sound passed through the right jugular vein entering the tricuspid valve. In two experiments pulmonary pressure was obtained directly from the branch to the left lower lobe, and in two instances both methods were used synchronously.

These pulmonary tracings likewise demonstrated that under regulated ventilation changes in blood pressure did not occur. If, however, the air compression was employed several minutes previous to the opening of the chest, a rise in blood pressure occurred which immediately fell to the normal level at the moment of opening. Moreover, if after the opening of the chest the positive pressure was allowed to exceed the limit necessary to overcome the elasticity of the lungs and to preserve oxygenation, changes in aortic and pulmonary pressure were manifest. Lowering the air pressure below the normal limits would cause a fall in blood pressure because of the dyspneic effect of insufficient lung ventilation.

From this series of experiments I conclude that in the presence of wide-open pneumothorax, under properly-adjusted air compression, changes in aortic and pulmonary blood pressure do not occur. Furthermore, in the absence of change in pulmonary pressure I am

further persuaded to agree with Professor Brauer that the intra-alveolar tension is no greater when produced by positive inflation than when caused by negative suction applied to the outer surface of the lung.

Some observers who have seen Professor Brauer's head chamber clinically applied in surgery of the human, state that cyanosis and dyspnea have been conspicuous factors. In such instances one or two avoidable conditions are present. If unnecessarily high pressure is employed, under-compression of the pulmonary capillaries ensues, the right heart may become engorged and a rise in pulmonary pressure occurs. This should not occur, however, except in the hands of unskilled operators. The more frequent cause of dyspnea in these cases is incomplete ventilation of the lung alveoli due sometimes to the insufficient supply of oxygen, but more often to the stagnation of carbon dioxid, the escape of which is not adequately provided for either in the construction of the apparatus or in its manipulation.

When double wide-open pneumothorax exists, the respiratory excursion of the lung is practically *nil,* with the exception of the slight expiratory effect in the rise of the diaphragm. In other words, the alveoli become dead spaces held in a given degree of steady inflation by air compression. The exchange of gases in these alveolar spaces is essential but difficult in the absence of the help of the thoracic excursion. A limited dead space is, as has been stated by Yandell Henderson, essential for the retention of the required amount of carbon dioxid.

My experience has been, however, that in the use of a positive pressure apparatus the tendency is to the over-retention of CO_2 from an excessive dead space resulting in excess of CO_2, slowing of the pulse and dyspneic respiration, rather than a tendency to lack of CO_2 (acapnia), cardiac tetanus, and apnea, described by Henderson as the symptoms of hyperventilation.

I have done six experiments by the method of Volhard and Sollman introducing oxygen by catheter through a tracheotomy wound to the bifurcation of the bronchi, with both chests wide open and lungs collapsed.

The alveoli of a two-thirds collapsed lung can thus be ventilated and the animal kept alive. Not only is a direct access of oxygen to the partially collapsed alveoli thus established, but a ready escape and flushing out of carbon dioxid is also provided through the tracheotomy wound around the catheter. In one of two attempts I found it possible to maintain oxygenation by similarly introducing air and ether mixture by tracheal catheter, with both chests opened and both lungs collapsed.

The secret of the success of these tracheal experiments with semi-collapsed lungs is the absolute prevention of a dead space for carbon dioxid retention. In order to avoid tracheotomy and introduce air by the mouth, the lungs must be kept inflated by resisting the outflow of the air compression. The aërating surface is thus increased and the ventilating air is kept in motion as in the tracheal experiments.

I have also observed that when the lungs are held in expansion by a strong resistance to the escape, together with a low supply of air compression, that dyspneic signs of incomplete ventilation come on, and from these observations I have been led to attempt every possible means of improving the gas exchange in the alveoli and thus preventing an absolute dead space. I have, therefore, increased the pressure and rapidity of flow of the afferent "fresh air" by using higher compression, up to about three pounds, yielding a cubic foot of air each minute.

The resistance to the efferent air I have correspondingly diminished so that the lung inflation has remained at its original level. This profuse flushing out of the alveoli is, therefore, a principle which I recommend to

prevent the over-accumulation of carbon dioxid, and since its employment I have seen no tendency to dyspnea or cyanosis.

SUMMARY.

The results of thirty operations under positive pressure with 70 per cent. recoveries were encouraging.

Thirty operations and twenty-five experiments proved that emphysema and circulatory changes do not occur with a properly regulated apparatus.

In the use of positive pressure the escape of deoxygenated air must be amply provided for.

I would express my thanks to Prof. Walter B. Cannon for valuable suggestions in the blood-pressure experiments; and to George Adams Leland, Jr. (Harvard Medical School, Class of 1911), for his able assistance.

THE POSITIVE PRESSURE METHOD OF ARTIFICIAL RESPIRATION

WITH ITS EXPERIMENTAL APPLICATION TO THE SURGERY OF THE THORACIC ESOPHAGUS.

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It is not the intention in this paper to go over the history or to cover the literature of artificial respiration. There are two distinct procedures included in the term. The first applies to postural methods, the second applies to that produced by apparatus. The latter is used in the surgery of the chest. This may again be divided into the positive pressure and the negative pressure methods. It makes little difference which of these is employed. It is in accordance with obvious surgical principles to apply the most expedient.

Matas,[1] Brauer,[2] Tuffier,[3] F. T. Murphy,[4] H. H. Janeway and others have employed positive pressure. Sauerbruch[5] has been the chief advocate of negative pressure. Woillez,[6] in 1876, also employed a negative-

1. Matas, R.: Tr. South. Surg. and Gynec. Assn., xii, 52-82; Artificial Respiration by Direct Intra-Laryngeal Intubation, Am. Med., Jan. 18, 1902.
2. Brauer, L.: Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1904, xiii, 496.
3. Tuffier, T.: l'Ouverture de la plèvre sans pneumothorax, Presse méd., Jan. 27, 1906.
4. Boston Med. and Surg. Jour., April 13, 1905, cliii, No. 15, pp. 428-431.
5. Sauerbruch, F.: Mitt a d. Grenzgeb. d. Med. u. Chir., 1904, xiii, 400-480; München. med. Wchnschr., Jan. 2, 1906; Zentribl. f. Chir., 1905, xxxii, 82; Beitr. z. klin. Chir., 1905, xlvi, 405-494. Stetten, DeWitt: The Experiments of Sauerbruch in the Field of Esophageal Surgery, New York Med. Jour., June 10, 1905.
6. Bull. de l'Acad. de méd., series 2, 1876, v., 613.

pressure box. Its application was, however, different from that of the Sauerbruch chamber.

As the technic of intrathoracic work shall improve, and as the underlying difficulties shall be more thoroughly understood, artificial respiration as an aid will become more general. The possibility of intervention in thoracic visceral disease has been made clear by Tuffier, Maffei[7] and others. Dr. Sauerbruch's classic work has given a new impetus to the interest in surgical intervention in the chest.

There are difficulties in the surgery of the chest that are not present elsewhere. The chest is a more or less rigid cavity in which the viscera lie deeply anchored. The condition of negative pressure exists. The walls remain rigidly outstanding after either partial collapse of the lung or the removal of part of the enclosed viscera. This latter causes a failure of the viscera to fill the chest at once completely after it has been opened.

There is an apparent tardiness in the serous membranes of the chest to form rapid and plastic adhesions as compared with the peritoneum. Whether this is real or only due to the other conditions within the thorax has not yet been worked out. As to the fibrous adhesions, it is well known that they may be very extensive. In other words, speaking surgically rather than histologically, there are two degrees of adhesions: the first is the plastic form, the second is the fibrous or organized. The rapid development of the first-mentioned is the element which makes a large part of the intra-abdominal work possible. The rate of formation of plastic adhesions within the chest is apparently slower. There is a marked susceptibility of the pleural cavity to infection.

After operations in the chest, as elsewhere, septic manifestations may occur. When these have once occurred, it is very hard to establish drainage. This has

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7. Jour. de Chir. et Annal. de la Soc. belge de Chir., 1906, vi, 380-390.

Fig. 1. Result of sectioning operation using silk sutures to make the anastomosis: 1, point of anastomosis which was sequestrated in the abdominal cavity below diaphragm 3; 2, the normal esophago-gastric opening closed with silk sutures.

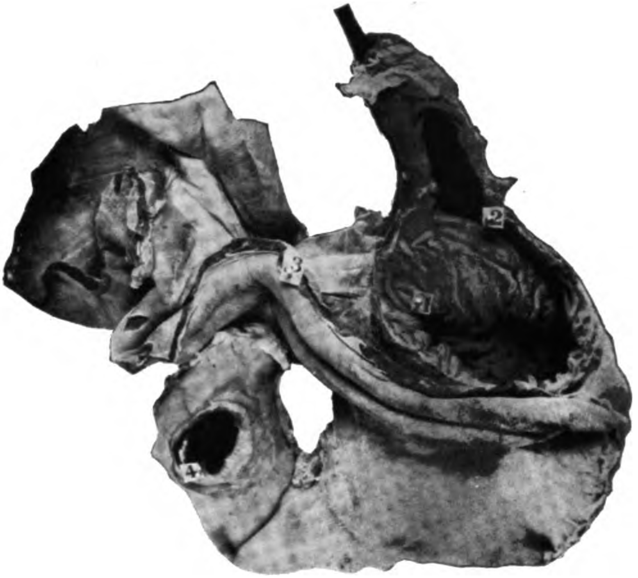

Fig. 2. Side-tracking operation by means of a Murphy button: 1, is on the edge of the normal esophageal opening; 2, is on the edge of the new stoma; 3, is the diaphragm; 4, is the Murphy button impacted in the pyloric end of the stomach, causing death two weeks after operation.

Fig. 3. Side-tracking operation by means of a Murphy button containing an obturator in the male portion: 1, normal esophageal opening into stomach; 2, new stoma; 3, diaphragm. (It must be understood that in these operations the cardiac portion of the stomach was drawn up through the diaphragm into the chest and became thereafter an adventitious thoracic viscus.)

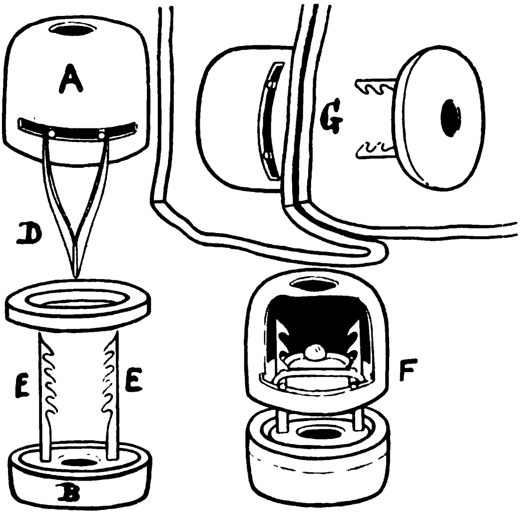

Fig. 4. Special button for esophago-gastric anastomosis (side-tracking operation) : A, gastric half of button ; B, esophageal half ; C, floating ring (elastic) for maintaining continuous pressure on tissues (this is made now as a spring ring) ; D, forceps for releasing spring which engages needles, E, E ; F, complete button partially closed ; G, method of uniting halves of button by perforating walls of esophagus and stomach by the needles (the portion of the walls thus included between the halves of the button undergoes necrosis from pressure and sloughs out in a few days). The new stoma shown in Fig. 6 is the result of such a process.

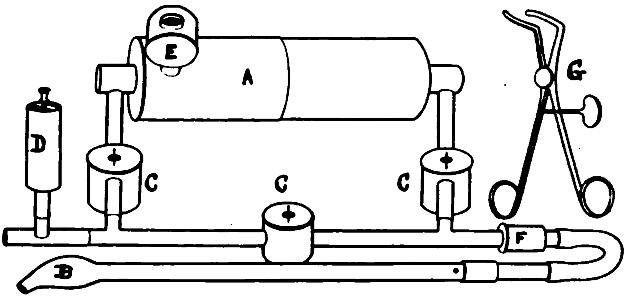

Fig. 5. Apparatus for applying positive pressure in artificial respiration ; A, ether chamber filled with gauze ; B, intubation tube ; C, C, C, valves used to direct current of air either through ether-chamber or directly to intubation canula ; D, safety valve ; E, inlet for fresh ether ; F, air-filter ; G, clamp for holding tube in place.

Fig. 6. Stomach removed from dog ten days after operation: 1. 1, glass rod passing through esophagus and normal cardiac orifice of stomach; 2, new stoma made by button shown in Fig. 4; 3. diaphragm.

been our experience in the Research Laboratory. Infection, when present on one side, may rapidly involve the other. We have found in dogs that opening one side of the chest usually means collapse of the lung on the other side as well, unless the lungs are kept inflated by some artificial means, and frequently we have found a communication of one pleural cavity with that of the opposite side. Prof. George S. Huntington regards these openings as artifacts. Furthermore, even if not patent, the mediastinum in dogs is very thin and easily movable, and does not offer the resistance to atmospheric pressure, when one side is opened, that is found in the human being. On this account it would seem that operations for certain conditions in the human subject will prove more successful than the same class of operations for experimental purposes in dogs. This may seem an extraordinary statement, as it is the popular belief that dogs are more resistant to septic infection than are human beings. Our researches, however, have shown that dogs are not as resistant to infection as is commonly believed. In operations in the chest we may get infection from the skin, the severed bronchial tubes, or the opened hollow viscera. Operations on the lungs appear to be less frequently followed by empyema than operations on the alimentary canal. In work on the lungs it is important to have all the cut ends of the bronchial tubes closed in to prevent it. Any method that accomplishes this well should succeed. In a recent article by Samuel Robinson,[8] of Boston, very good results have been reported. In a previous paper,[9] one of us has outlined a technic for the prevention of sepsis from the bronchi. In work on the esophagus, sepsis more frequently follows, unless special points in technic applicable to the chest are carefully observed. Whether this is due to the aspirating of air down the esophagus while it is opened, thus contaminating the field of

8. Ann. Surg., February, 1908, xlvii, No. 2.
9. Green, N. W.: Surg., Gynec. and Obst., May, 1906, ii, No. 5, 512-538.

operation, or whether it is due to subsequent leakage from some mechanically imperfect closure is hard to determine. It may be from both. H. H. Janeway has suggested that it may, in some degree, be due to the suction of the negative pressure aiding intra-thoracic seepage along the stitches, or retrograde leakage between them.

Dr. Sauerbruch has had very favorable results with the aid of some mechanical device such as the Murphy button. We think that this is due to a more perfect closure of the anastomosis wound and of the lymphatics than can be made by stitches, for when properly applied it makes a tight apposition of the visceral surfaces. This, unlike the union made by stitches, is an uninterrupted pressure circle. That made by stitches, on the other hand, even if they be continuous, must have points of varying pressure throughout its circumference. These theoretical points have been suggested to us by the difference in mortality in practically comparing the two methods. Our own experience leads us to believe that some mechanical device which will establish an anastomosis with absolutely no soiling of the serous membrane, forming at the same time a tight joint, will prove of the greatest assistance in rendering operations of this nature free from disastrous infection. Dead spaces within the chest should be overcome as much as possible, at the termination of the operation by increased air pressure. The absence of omentum with its coapting power is an unfavorable feature which may hinder success. We have carried omentum into the chest and applied it to the wound in one instance. The constant motion of the diaphragm may be a factor which militates against proper union after operation. We have stretched the diaphragm on the operated side, and also interrupted the function of the phrenic nerve in an effort to overcome this.

The difficulty of establishing drainage may, in part, be overcome in the human by some sort of aspirating

device.[10] In our experimental work on dogs this is hardly applicable.

The indications for operation on the esophagus are: stricture of the esophagus, carcinoma of the lower end or of the esophago-gastric juncture, diverticulum of the esophagus, and foreign bodies within the esophagus.

The operations that we have undertaken in the Surgical Research Laboratory on the esophagus may be classified under two types. In one, the esophagus was sectioned, reuniting the proximal end with the cardia of the stomach (Fig. 1). In the other, there was a side-tracking of the cardiac orifice similar to the method of Biondi.[11] The sectioning operation was done with the aid of sutures and of the Murphy button. The results have not been encouraging. The greater amount of traumatism and the more protracted duration, together with the difficulty of making a perfect closure, have limited our success. The side-tracking method has been accomplished with the aid of the twine triangular stitch elaborated in this laboratory,[12] and with the aid of the Murphy button (Figs. 2 and 3). We have also made use of a special button (Fig. 4) designed (by N. W. G.) with the idea of causing an anastomosis with no further opening of the viscera at the time of operation than two needle-like punctures made after the serous surfaces have been coapted.

We have used during these procedures an apparatus for artificial respiration described in previous communications.[13]

It may be well here to present a diagram of it (Fig. 5). Ether has always been the anesthetic used. The loss of body heat was always considerable, but this, in part, has been overcome by warming the ether vapor before sending it into the air-passages.

10. Seidel, H.: Deutsch. med. Wchnschr. Feb. 22, 1906. Bryant, J. D.: Surg., Gynec. and Obst., 1906, iii, 296-302.

11. Gosset, A.: Rev. de Chir., 1903, xxviii, 694.

12. Maury, J. W. Draper.: Studies from the Laboratory for Surgical Research, Columbia University, 1907, i.

13. Green, N. W., and Maury, J. W. Draper.: Ann. Surg., Oct., 1907, xlvi, 544-548.

It may be of interest here to describe in detail one type of procedure which has seemed to us particularly satisfactory. The animal was first placed under ether and the intralaryngeal canula inserted and held in place by a clamp, pinching the tube just oral to the hyoid bone. Through the mouth were introduced, first into the stomach and then into the esophagus, the halves of the button shown in the diagram. The esophageal portion, being the one with the needles attached, was introduced and guarded by a long alligator-jaw forceps. This was left in place while the chest was opened at the level of the eighth rib on the left side. The eighth rib was removed, stripping from it its periosteum, as suggested by Janeway. This gives a much better opening than the intercostal incision and makes it far easier to close the chest at the completion of the operation. The amount of air introduced was regulated by direct inspection of the lung. The seventh and ninth ribs were pressed apart by a self-retaining retractor and care was taken to protect the wound from contamination by a suitable covering. The diaphragm was opened in its tendinous aponeurosis, and the cardiac portion of the stomach drawn up through the opening into the chest and sutured in place to the edges of the diaphragmatic wound. This suture was a continuous one and several reefing stitches were taken in the stomach to one in the diaphragm. This close stitching of the stomach was found to be necessary on account of the tendency of the abdominal viscera to cause fatal prolapse into the chest. We were careful not to include the blood vessels of the stomach in our sutures. Feeling through the stomach wall, we grasped the first portion of the button, previously introduced, and drew it through the new diaphragmatic opening into this cul-de-sac. The forceps were then removed from the esophageal half, the surfaces of the stomach and esophagus brought in apposition and the two halves of the button pressed tightly together. They were held by the spring which engages

the serrations at the side of the needles. This completed the intrathoracic part. The chest wall was then closed in layers. The operation here described consumed fifty-five minutes. At the end of ten days the dog was given a lethal dose of ether. The stoma shown in the photograph was found present (Fig. 6).

We wish to express our appreciation to Mr. Arthur G. Sullivan for his assistance, to Drs. H. H. Janeway and N. B. Leggett for many valuable suggestions and to Dr. Robert M. Brown for his skillful mounting of the specimens.

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DISCUSSION

ON PAPERS OF DRS. SCHÄFER, SAUERBRUCH, ROBINSON, GREEN AND MAURY.

DR. GEORGE W. CRILE, Cleveland, Ohio: The ultimate object of artificial respiration is that of affording the fixed tissues, especially the central nervous system, the exchange of gases necessary to life. To accomplish this the circulation and the respiration are equally essential. Air hunger is just as marked in failure of the circulation as in failure of lung ventilation. When the total amount of blood and the vigor of its circulation is above normal less than normal respiratory effort is needed. For the best results in artificial respiration, then, a good circulation is required. In considering artificial respiration one must take into account the effect which alterations in the intrapulmonary pressure exert on the circulation. The blood pressure in the pulmonary capillaries is low. Intrapulmonary pressure is exerted directly on all these capillaries; hence, the entire blood stream is affected. The lower the blood pressure the less intrapulmonary pressure is necessary to block the blood stream. In sheer emergencies there is opportunity for only the simple methods, of which the most effective is the one that supplies a sufficient exchange of air and gives the greatest aid to the circulation. These requirements are fully met by the methods of Professor Schäfer. The thread of life may for a time be unbroken if even a very small amount of oxygen be supplied. When one tries to kill an animal by asphyxiation, one is constantly surprised at the wonderful rejuvenating power of only a slight amount of air. Both experimental and clinical evidence show that the circulation may be remarkably energized by pressure on the thorax and abdomen. In the majority of operative emergencies there are many obstacles opposing the change from the supine to the

prone position. I conclude that rapid, rhythmic pressure on the thorax, with the patient lying on the back, when the prone posture is contraindicated, is the simplest and most generally useful emergency method.

As for planned cases of artificial respiration, I would add a strong word of caution against any considerable change in the intrapulmonary pressure. There is scarcely any more certain and sudden method of killing an animal than by an excessive intrapulmonary pressure. Now, the circulation in a normal animal may not be much hampered by a certain amount of increased pulmonary pressure, but in the states of low blood pressure the circulation may unexpectedly collapse. Recent experimental research has proved that the circulation of an animal carefully overtransfused with blood from another animal becomes stable and the blood pressure is raised. Changes in intrapulmonary pressure affect the circulation far less, and such an overtransfused animal endures intrathoracic pressure far better. When there is an increased volume of blood and increased circulatory vigor, the respiratory movements diminish. Conversely, when there is a failing circulation, respiratory movements become increased. In planning a hazardous chest operation, if the heart is normal, the chances for a successful issue seem to be greatly increased by first rendering the circulation stable. There are a number of methods whereby a sufficient amount of oxygen may be supplied, but there are few methods that do not in the case of weak circulation threaten the circulatory stability. On the whole, the problem of supplying the required amount of oxygen *per se* is not difficult. The real difficulty is met in providing lung ventilation without interfering with a weakened circulation.

Dr. Willy Meyer, New York: Surgical pneumothorax has, up to date, been the principal barrier to further advance in intrathoracic surgery, and that up to a time when abdominal surgery has had its triumphs the world over. Dr. Fell of Buffalo devised and Dr. O'Dwyer improved the apparatus for intubation, and Dr. Matas has further improved it, adding an arrangement for general anesthesia. But tracheotomy or intubation is not what we surgeons want for practical purposes. Tracheotomy means a grave addition to the surgical trauma, especially for older patients, and an intubation apparatus is unreliable for cases of retching and vomiting. Besides, the accumulating intrabronchial secretions can not be expectorated. Even rectal anesthesia would probably not overcome this trouble.

What is essential for good surgical work is that the narcotizer should have free access to the patient's head, especially the mouth, at all times. He must be able to turn the patient's head to one side, and clean out his throat just as thoroughly and easily as he is accustomed to doing this during other operations.

In 1893 the late Professor von Mickulicz charged his assistant, Dr. F. Sauerbruch—to-day our guest—to find a more practical procedure in order to overcome the dangers of pneumothorax. This he accomplished by constructing an operating cabinet, within which he has done five operations on the human subject, and a great many on animals. The beauty of this cabinet is that it can be used for negative as well as for positive pressure. If the operation with negative pressure is desired, the patient's head is placed outside of the cabinet and the body inside; if positive pressure is desired, the head is placed inside and the body outside.

In either case the anesthetizer has free access to the patient's head. If he is inside of the cabinet and positive pressure is used, the excellent ventilation provided for will prevent his becoming anesthetized himself. The same suction pump, arranged with a T tube, provides for negative and positive pressure. This cabinet allows of free intrathoracic operating with impunity. Simultaneously with Sauerbruch, though independently, Professor Brauer of Marburg, in 1904, designed an apparatus for positive pressure which though since improved, labors under the same drawbacks as all other devices for positive pressure, namely, that any accidents, occurring in the course of the anesthesia, can not be met properly.

The drawbacks to a more general use of Sauerbruch's cabinet thus far have been its cost and its size. In its present shape, however, it is much less expensive (about one-third of its original price) and, to cheapen it still more, Dr. Sauerbruch has planned to have one made of canvas, properly painted. He also intends to have a small cabinet placed on castors so that it can be wheeled to the patient's bedside, should it become necessary to change the first dressing under pressure difference. Sauerbruch has solved the problem in either direction. It now remains for us surgeons to adopt and try the procedure.

We all know that esophageal cancer is the least malignant of all the types of carcinoma, including the colonic. And yet, what do surgeons do in these cases up to the present time? They perform gastrostomy or dilate the stricture as long as this can be done, and then let the patients die. This must be changed. In resecting the esophagus by the intrathoracic route, or in attacking a cardial cancer from the abdomen with the help of osteoplastic resection of the costal arch, we must be prepared for opening the pleural cavity. The abdominal operation also must, therefore, be done under differential pressure. The greater majority will, as a matter of course, be done by the intrathoracic route. Professor Sauerbruch has greatly improved the operative technic. He closes the proximal cut end of the esophagus by infolding, and after having pulled the stomach into the thorax—and this for the reason

that the esophagus can not be stretched—does esophago-gastrostomy by means of Murphy's button introduced on a long forceps or stiff bougie by way of the mouth. Care must be taken to have the stem of the button penetrate also the pleura in order that this serous membrane may be pressed against the peritoneal covering of the stomach within the grasp of the button. The latter has of late been improved for this operation at the research laboratory of the College of Physicians and Surgeons of New York. Professor Sauerbruch, in this way, saved twelve out of thirteen dogs experimentally operated on; surely an excellent showing. The nine human beings operated on by him in the same way were afflicted with malignant esophageal stricture. All died, but every one of the patients was in a decrepit condition when the operation was undertaken, and death was not due to any defect in the method of differential pressure in a single instance. There can be no doubt that if we operate early the results will be correspondingly better. Surgeons should work together toward this end. We must succeed in doing intrathoracic resection of the esophagus for carcinoma under negative or positive pressure and save the patient in early cases as long as the lymphatic glands are not involved. If such involvement has occurred, resection is useless, as it indicates that the growth passes the borderlines of the esophagus.

DR. H. H. JANEWAY, New York: The first experiments which I made in intrathoracic surgery were performed under conditions of negative air pressure. These experiments were made in a hermetically sealed chamber, large enough to hold the operator and two assistants. The work done within this chamber was confined to resections of lobes of the lung, and sufficient successful work was done to render the experimenters familiar with the conditions or operating under negative air pressure. These experiments, however, were interrupted by peculiar outside circumstances, and since then I have adopted the positive pressure method of Professor Brauer. I have found the negative and positive pressure methods equally satisfactory.

The form of apparatus now used to supply positive pressure is essentially the box designed by Dr. Brauer of Marburg and Dr. F. T. Murphy of Boston. The experiments with this apparatus have been entirely limited to attempts at resection of the oral end of the stomach and the aboral end of the esophagus, and certain points of importance have been developed. The first is the fact that greater asepsis must be maintained in intrathoracic surgery than elsewhere in the body. I believe that raw edges of mucous membrane can not be exposed here with the same impunity with which they are within the abdomen. The second fact developed is that resections within the thorax can not be safely, or perhaps even successfully, performed by the suture method. In a series of operations done

by this method there was a mortality of 100 per cent. The anastomosis was completed in each case in such a way as not to expose in any stage an infected edge of mucous membrane, and a double line of circular Lembert sutures were introduced. Nevertheless, I doubt whether in any one of them the anastomosis was or could be made tight enough to resist the cupping effect of the partial vacuum existing within the pleural cavity after the chest wall was closed. Indeed, the condition may be likened to a Bier's hyperemia with many of the advantages turned into actual disadvantages. The insufficiency of the suture method to prevent leakage was confirmed by test anastomoses made with the button-and-suture method outside of a dog's body, on segments of intestines removed, and subsequently subjected to a hydrostatic pressure of 250 mm. of mercury. My experience, therefore, and Dr. Sauerbruch's agree that the successful accomplishment of this anastomosis requires the use of the button. The Murphy button is unsatisfactory from the standpoint of time and from that of aseptic introduction. The new button, on the contrary, is quickly and cleanly introduced, and its use constitutes a decided advance. In construction of the button I have suggested to Dr. Green that an elongation of the spring ring would so protect the perforating knives that no harm could be done with them during the introduction of the button, and also that the cutting edge of the knives be broadened out a little below the point so as to give immediate drainage. The success of intrathoracic-gastroesophageal resections depends on hermetically sealed circle of union. This is not safety attempted by suture or by the Murphy button. We deem it most important to provide against the loss of heat during the operation. The inspired air within the box is warmed, and in order to diminish the general and local shock accompanying intrathoracic work by an adequate supply of external heat to the body of the subject we have made use of an electric pad, with very definite beneficial effect. In my apparatus the manometer is situated within view of the operator, his assistant and the anesthetist. This manner of regulating the air pressure has been utilized rather than any automatic arrangement; first, because of its simplicity; and second, because it was very rarely found necessary to change the position of the stop-cock, for the purpose of maintaining a constant pressure, after the operation had started. The position of the glass porthole is such that the subject being anesthetized is constantly within full view of the anesthetist. Inside the box is a bracket for the support of the head of the subject. There are also lights along the rear wall. These serve the double purpose of affording illumination and of keeping the atmosphere within the box at the desired temperature. This is a most important point, for in the opening of the pleural cavity, and the exposure of this large surface to the room

temperature, much heat is lost, and the respiration of warm air is helpful in keeping the blood at the body temperature. With a temperature of 94 degrees inside the box, the post-operative temperature of some of my dogs has been 101, or about normal for this animal. One hand is sufficient for managing the anesthesia. In an emergency, however, the other hand can be introduced through the second opening.

DR. GEORGE E. FELL, Buffalo: I happen to be probably the first man to demonstrate practically the value of forced artificial respiration in saving human life, and that is now over twenty years ago. I was professor of physiology in a medical school and also a medical practitioner. When I began my work of "forced respiration," the medical world (through Marshal Hall), said that we must not use bellows of any kind. In my physiologic work in opening the chests of dogs I discovered there was much error in this dictum. After I lost my first patient—a man who had taken morphin—after trying the Sylvester method I determined to use my laboratory methods in the next case. A man took 16 grains of morphin. After working two hours and a half by this method I saved his life. On the knowledge of the defects in this apparatus I built the apparatus I now use in my work and exhibit here.

The same principle can be applied to thoracic surgery, and readily applied. With this apparatus I breathed for 18-day-old infant who had been given one grain of morphin accidentally. The little one was held in a tub of warm water when I saw her, and had been under the influence of the poison for two hours. I had no hope of saving the baby's life. I did a tracheotomy, passed a catheter into the trachea and built it up with larger catheters until I could connect it with my apparatus. I succeeded in keeping the child alive for two hours, but it had received so much morphin that it was impossible to save its life.

In all my work I have been trying to simplify the method so that it can be used as an emergency apparatus. A medical student, employed in the postoffice at night, began to take nux vomica to brace him so that he could continue both his work and his studies. One night he took instead several hypodermic injections of 1/40 grain of strychnin; then he began to notice the contractions of strychnin poisoning. In order to stop this he took morphin hypodermically. He was found unconscious in the morning. I began breathing for him with this apparatus, using the hard rubber face mask which prevents the air from passing outside. I breathed with that for a while, but found it unsatisfactory. Then I tried tracheotomy, using my tracheotomy tube, and respired for him from 9 a. m., July 3, until 10 p. m., July 7—four days and three nights of interrupted respiratory work. He lived, and is now practicing medicine on the Panama Canal hospi-

tal service. A boy 16 years old broke some ribs while playing ball and took chloroform to overcome the pain. After this he took about 26 or 28 grains of morphin in a tumbler of water. I breathed for him through a tracheotomy tube for about eighty hours and saved his life.

When you force air into the lungs you expand them as in normal respiration. I have a pair of bellows of which three movements suffice for the inspiration and three for the expiration in an adult. A valve controls the inspiratory and expiratory action. The apparatus is simple and satisfactory. As the air goes from the bellows it passes through a channel out of the valve, tending to produce a slight vacuum; if attached to the lungs it has a slight tendency to draw out air, which slightly aids expiration. When you press down on the valve the air passes into the lungs. Attached to the valve is a tube connecting with the oxygen apparatus. When you press down on the valve both air and oxygen are forced into the lung. This apparatus illustrates the so-called positive method. In the surgery of the chest both the positive and negative methods will prove of great value. Professor Schäfer's new method is a step in advance, but taking equal cases it will not accomplish what positive forced artificial respiration will, and is not applicable in surgery of the thorax.

Dr. John B. Murphy, Chicago: The term "pneumothorax" is misunderstood. Pneumothorax, *per se*, does absolutely no harm, as I demonstrated and reported in a paper ten years ago. It is the absence of the expiratory exchange that makes the condition of pneumothorax a dangerous one. In 1,700 cases of artificial pneumothorax, by nitrogen injections, where I used from 30 to 180 c.c. of the gas, I did not have a single case of collapse from the pneumothorax. Why? Because it is not the admission of air into the pleura that makes the danger. It is the absence of respiratory change that makes the condition a dangerous one. You can collapse one lung completely, immobilizing the mediastinal septum, without interfering with the patient's comfort and ease.

Dr. Sauerbruch's cabinet is admirable; it meets every indication. It can be used for negative and for positive pressure, but it is not a question of the air that gets in; it is the fixation after the air is admitted. For instance, remove a section of a dog's chest wall; the mediastinum vibrates freely and ruptures in three to five minutes. On the other hand, let the air enter and clap one hand over the opening, and the dog goes on breathing just as if nothing had happened. If the opening be made large and not small, the subject will not be under respiratory difficulties. It is the little opening that admits more air than goes out that produces the plus pressure, presses the diaphragm to one side, as so commonly occurs in rupture of the lung, and causes the patient so much trouble. The doctor can overcome the difficulty in a moment by taking

a large trocar and inserting it between the ribs. The trouble is overcome in a minute, as far as the plus pressure and dyspnea are concerned. Where there is hemorrhage from the lungs, so common in everyday practice, a plus pressure can be produced in exactly the same way. By introducing a trocar, covering the end with cotton so as to prevent the introduction of germs, with each inspiration covering the end of the trocar and removing the obstruction when the subject expires, one can produce a plus pressure that will stop the primary hemorrhage. It will not stop secondary hemorrhage, but a plus pressure is obtained at once simply by placing the finger over the trocar.

With these points kept in mind we can look for better results in the treatment of surgical lesions of the lung. My enthusiasm of ten years ago has diminished materially, however, on account of the incurability of so many lesions of the lung by mere extirpation of a portion of it. But we should have these things under our control in a measure at least because of their scientific value and the probability that they will become of greater practical value. The mere removal of a fragment or lobe of the lung was done four hundred years ago. I have opened a dog's chest, drawn out his lung and let it flatten on the surface, merely preventing the air from going in and out through a small opening, which produced a plus pressure and diminished respiratory exchange. It is this diminished respiratory exchange that must be kept in mind, and not the mere presence of air in the pleura.

Dr. Victor J. Baccus, Chicago: At the last meeting of the French surgical congress Broca remarked that a pneumothorax, either accidental or intentional, was not always dangerous to the patient. In his operations on the chest entailing the opening of the pleural cavity, he allows the air to enter through a small opening, thus permitting the lung to collapse slowly. He advises the withdrawal of the anesthesia temporarily—a few minutes suffice. The patient learns quickly to breathe with one lung. Then the operation is continued. In Broca's hands pneumothorax has never proved fatal.

Dr. M. B. Tinker, Ithaca, N. Y.: We have, most of us, been accustomed to make use of the methods of Hewitt or Sylvester in cases of respiratory failure on the operating table and of foreign body in the air passages in which the patient had not breathed for some time. In case no apparatus is at hand, Professor Schäfer has shown conclusively that the older methods do not give the patient sufficient air. In abdominal and many other operations it is obviously impracticable to turn the patient on his face to practice Professor Schäfer's method. It occurred to me in teaching anesthesia, some time ago, that we could use a combination of the older methods. If we elevate the arms above the head, thus opening the chest wide, we produce forced inspiration, while to

produce expiratory effort we bring the elbows together over the chest and compress the chest, thus getting the action of the Hewitt and Sylvester methods combined. A test of this combination method in the physiologic laboratory of Cornell University shows that it gives a fairly satisfactory amount of air to the patient. Before I had tested this method in the laboratory, however, I had used it in two cases of foreign body in the air passages. In one case the patient had stopped breathing for five minutes; in both cases the method was successful.

PROFESSOR EDWARD A. SCHÄFER, Edinburgh: Dr. Tinker failed to state how many minutes he continued this artificial respiration. If you are going to take the trouble to draw the hands up above the head, you are doing a lot of useless work, because you get abundant air into the lungs without such a procedure. In cases of drowning the prone position is most strongly indicated.

DR. F. SAUERBRUCH, Marburg, Germany: No doubt some of you will expect me to answer the question as to whether, for the performance of operations under artificial respiration, we should use the apparatus for positive pressure, as devised by Brauer, Heller, Robinson, Meyer, Kuhn and others, or whether we should employ negative pressure. The difficulties of any kind of artificial respiration consist in the danger to the lung tissue. If, in animals, no damage results from pumping air into the lungs artificially, this must be ascribed to the fact that the animals experimented on are healthy beings. In the human subject needing operation this is different. Here the changes wrought are frequently so great that artificial respiration of any kind is by no means an indifferent factor. To my mind, it can only be a question of whether positive or negative pressure should be employed. The physiologic apprehensions regarding the positive and negative pressure methods have been shown, by the works of Brauer, Seidel, Meyer and Dreyer, to be without foundation. The points in favor of the apparatus for positive pressure are that it is smaller, cheaper and easier of transportation and that communication between operator and anesthetizer is more readily established.

An objection frequently advanced against the chamber for negative pressure is that its use is intolerable to the subject on account of the heat. This objection, however, is unfounded, inasmuch as in the chambers of latest construction the ventilation is so excellent that the air in the chamber does not become overheated any sooner than in the ordinary operating room. Nor is the cost of such a chamber as great as is generally supposed. It is possible to obtain a satisfactory apparatus for from $1,000 to $1,200. Furthermore, any ordinary room can be converted into an operating chamber for operations to be done under differential pressure. All that

is necessary for the purpose is to provide for a hole through the door or wall of the room through which the patient's head can be passed, and to supply a suction pump, which by the introduction of the T tube can easily be converted into a pump for positive pressure. Eventually one might construct a light, easily portable chamber of duck or canvas which would answer all practical purposes. A point of great importance, in my opinion, is that in all forms of negative pressure apparatus we are in a position to arrange for a reliable narcosis (also when arranged for positive pressure) so that disturbances due to vomiting, the danger of aspiration as present when other apparatus for positive pressure is used, are not encountered. Recently we discovered another advantage of negative as against positive pressure, namely, that in case of "tension-pneumothorax" and consecutive emphysema of the mediastinum and subcutaneous cellular tissue the mere opening of the thoracic cavity under negative pressure is sufficient instantly to relieve this dangerous condition. With positive pressure this is impossible for physical reasons.

DR. SAMUEL ROBINSON, Boston: One side of the human chest has often been opened without the use of any apparatus and without the onset of alarming symptoms of pneumothorax. Operations fatal to the normal dog have been successful on the human being. There are two reasons for this: The mediastinum of the dog is not a rigid partition separating the two sides of the thorax, but a fluttering membrane which in the presence of a one-sided pneumothorax yields to respiratory variations of the intrathoracic pressure of the unopened side and thus seriously affects the function of the sound lung. The human mediastinum, on the other hand, is a firmer structure with better anchorage. Hence the opening of one chest interferes to a less extent with the excursion of the lung of the unopened side, and one lung can to a certain extent compensate for the loss of the other. Furthermore, operations on the human being are generally in the presence of pathologic conditions in which the dangers are lessened by pleural adhesions and thickened mediastinum. What better proof is there, however, of the dangers associated with opening the human chest without apparatus than the reluctance of operators to perform an exploratory thoracotomy. I believe in the simplicity and portability of the positive pressure apparatus. There is need primarily of an apparatus to render exploratory thoracotomy a safe procedure. Rhythmical inflation is a more complicated procedure and requires skilled administration to obviate its dangers. I believe that the best method is the employment of a constant pressure with ample supply. The tubes conducting this pressure to the respiratory tract should lead either to a face mask or to an intubation apparatus, and my purpose is to perfect this method until simple enough for practical usage.

Of the practicability of the method, as such, I am now convinced.

It is to be regretted that the discussion to-day has consisted in the results of animal experiments under positive pressure versus the results of operations on the human being under negative pressure. The latter would at first seem more convincing. Professor Brauer, whose absence at this symposium is much regretted, would have reported the results of the application of positive pressure to the human being as administered with his own apparatus and with modifications of it in European clinics. The operations performed with this simple method, although fewer than those performed in the negative pressure cabinet, are nevertheless equally promising in their results. The cabinet mortality may be higher than that of the positive method, but the serious nature of Professor Sauerbruch's esophageal operations must, of course, be taken into consideration. I urge you, therefore, to bear in mind that the results of operations on the human being under positive pressure have been favorable. We present the results of our animal experimentation to support the method on the basis of physiology and to report improvements in technic.

DR. N. W. GREEN, New York: The point Dr. Schäfer brought out is valuable. Atropin is a great aid in preventing the effect of reflex irritation in work on the chest. It is a cardiac stimulant. You probably well know the physiologic experiment with the frog's heart, which was excised, stopped by muscarine, and which began to beat again when atropin was dropped on it. We ought to bear that in mind in our surgical work to combat shock. In the experiments on dogs I have opened both pleuræ in some cases. In other cases I opened only one pleura. It is well to remember that the mediastinum is very movable in the dog and also in children. Opening one side in a child in case of an empyema or anything like that may be a very serious matter, unless some aid is present, because the mediastinum collapses so easily toward the side that is not opened. If by any chance you have given too much ether—and ether kills by failure of the respiration—you can resuscitate the animal or person by means of rhythmical inflation. If you have not rhythmical inflation, you can produce it by pressure with the hands on the chest. When failure of respiration occurs, quite a time elapses between the time when you have such failure and heart failure, and rhythmical respiration carried on during that time may save the life of your patient.

THE RENAL ORIGIN OF VESICAL CALCULI,

WITH OBSERVATIONS ON CALCAREOUS TUMORS OF THE BLADDER.

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The *raison d' être* of this paper is given by two observations which are apt to modify some of our diagnostic views in regard to calculus formation in the urinary tract. Both are, as it seems to me, of academic interest, as well as of more than ordinary practical importance.

The first of my conclusions was reached by my experience that during a space of four years I found among eleven cases of stone in the bladder nine in which the Roentgen method showed renal calculus at the same time. In those two, in which the renal skiagraphs proved to be negative, technical defects occurred, which made the result doubtful, the patients at the same time not giving me a chance to clear up a possible error. In none of the patients were clinical symptoms present which pointed to the presence of nephrolithiasis. In five of the cases skiagraphy was verified by the surgical operation. A preliminary report was made[1] on this coincidence, which contradicts the generally adopted axiom that concretions originate either in the kidney or in the bladder.

Now, while most authors believe that the majority of vesical calculi are originated in the kidneys, they still hold that a considerable percentage is primarily

1. Annals of Surgery, December, 1905.

formed in the bladder. Before the Roentgen era this opinion, based on a limited amount of experience which was gained rarely on the operating table and little more frequently during autopsies, had to be accepted because there was no proof to the contrary. The repeated recurrence of vesical calculus after thorough suprapubic lithotomy in some of my patients often suggested the possibility to me that with few exceptions the kidneys were the originators of the stone at preskiagraphic times, but the only proof of this assumption would have been exploratory nephrotomy on both sides, a procedure which could not be fully justified. Now, a simple photograph can give us more precise information on this point than a surgical maneuver, which, in spite of our greatly developed technic is by no means an indifferent undertaking.

In investigating the nascent state of calculus I am satisfied that such solid ingredients, which under normal conditions remain dissolved in the urine, for some reasons are precipitated. Such substances are the urates of soda and ammonia, uric acid, phosphates, oxalates and carbonates of lime, cystin and xanthin or uric oxid. *A priori* it appears to be obvious that these ingredients are more inclined to be arrested in the convolutions of the renal structures than in the regular surfaces of a normal bladder. If microscopic examination of the urine were made more frequently, the number of cases in which newly formed precipitates, i. e. gravel, are carried off by the natural passages, would be much greater than we, as a rule, assume. And it is by no means essential that an excess of the ingredients mentioned should be present in order to cause precipitation, because calculus-formation is often observed when the proportions of these solid contents are perfectly normal. Of course there must be an exciting moment for precipitation. In some instances such moments can be well recognized, as, for instance, in cases of local irritation, caused by the

introduction of foreign bodies which serve as a nucleus for incrustation. Such alluvial provokers may be broken fragments of a straw, of catheters, pins, thermometers, pencils or sealing wax, etc., as they are frequently found by cystotomy. Their provoking influence may be enormous, as can be proven by introducing a soft rubber catheter into the normal bladder in my operation for hypospadias. A catheter left *in situ* for not more than four days is apt to show such massive incrustations that their intravesical presence can be recognized on a skiagraphic plate.

Necrotic tissue, mucus and even blood-clots may also form a kind of magnetic attraction for the salts. In this connection I refer to my observations on tuberculous kidneys, in which calcareous foci were deposited which would be recognized on a Roentgen plate as such.[2] Here, as in the lungs, glands, etc., tubercle bacilli act as an exciting element for concrementation.

But where no such conspicuous element exists, the nature of the impetus for precipitation is to be regarded an unknown quantity, just as in the question of the formation of biliary calculi. While we know that they are originated through bacterial influence, we neither know wherein the essential element consists which makes bacteria enter the gall bladder nor what gives them the peculiar attractive influence.

The fact that bacteria are detected in vesical calculi does not prove that they are the cause of the formation. They may just as well be the consequence, at least we can say that calculi offer a most favorable soil for bacterial development. The only instances in which bacteria can be proven to be etiologic factors are represented by those cases which are due to the entering of parasites into the bladder. For instance, the *Distomum hæmatoibium* of Bilharz is found endemically in some parts of Africa, and its eggs form a kind of an alluvial

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2. Renal Skiagraphy. Arch. Roentgen Ray. London. February. 1905.

provocation for concrementation. The same applies to *Filaria sanguinis*, which is endemic in some tropical countries. How far the *Bacterium coliroli communis*, is so much suspected of playing an etiologic part in the formation of biliary calculi, is to be considered in regard to the formation of urinary calculi can not be determined at the present time.

Thus it becomes evident that nothing definite about the exciting element in calculus-formation is known except in the comparatively small number of cases in which either a solid foreign body or a parasite of a distinct character succeeded in entering the bladder.

But in the overwhelming majority of cases the question of whether the calculi were of renal or vesical origin could not be answered. Now, if a Roentgen examination of both renal regions were made in every case of vesical calculus, the regular recognition of renal calculus would answer this most important question satisfactorily. I have no doubt that with the exception of extraordinary conditions, like those mentioned above, the embryonic stage of the vesical calculus is in the kidney, in other words miniature calculi or gravel form in the kidney and either all or some of them descend through the ureters into the bladder, where they become the nuoleus for further stone-development. Or small fragments of renal stones separate themselves and descend into the bladder to be arrested there and grow. The cases of so-called ascending infection in vesical calculus should be taken *cum grano salis*, because the pyelonephritis found may just as well be due to renal concretions which were not recognized.

Microscopic examination of the calculi does not give us any more information as to their origin, because the tender organic miniature structure which permeates the calculous mass does not show any texture characteristic for one or the other organ.

It is true that the number of my cases is small, but if to some of you my observations should not prove the

renal origin of vesical calculi in a general sense, the undeniable facts brought out by them at least offer an entire new perspective of an etiologic, as well as of a therapeutic nature. In other words, after the extraction of the vesical calculus nephrolithiasis must also be treated. The experience that vesical calculus is but seldom found in women (5 per cent.) is also in favor of the renal origin of vesical calculi, since the short and wide female urethra permits of the easy escape of the small renal calculi which had descended into the bladder.

One of my most convincing cases is that of a boy of 10 years, from whom a large vesical calculus was removed by suprapubic cystotomy six years ago. The relief was complete for about a year, when the patient again began to suffer from the symptoms of vesical calculus. Three years ago I skiagraphed the vesical, as well as the renal regions, the result of which was the Roentgen plate shown in the illustration. It shows the presence of a large mulberry calculus in the bladder and a still larger triangular concretion tightly embedded in the parenchyma of the left kidney. The right kidney showed normal relations. It is of interest to note the small calculus near the lower surface of the large renal concretion, as it illustrates the manner in which smaller concretions may primarily form in the kidney to escape into the bladder, where they act as nuclei for future vesical stones. The examination of the calculi after their removal from this patient proved them to consist of oxalate of lime, the outer layers of the renal, as well as the vesical calculus, showing a smaller degree of density than the inner. As to further details I refer to my article in the *Annals of Surgery,* mentioned above, and to my experimental studies on the density of calculi.[3] My second conclusion is based on the observation that incrustations in vesical tumors are sometimes so abundant that calculus is diagnosticated. We know

3. Arch. Physiol. Therapy, March, 1906.

that before the introduction of cystoscopy, vesical calculi were often overlooked and a positive diagnosis of vesical tumor was generally made at the autopsy table only. In fact, our whole diagnostic armamentarium consisted in the steel sound, which often missed the calculus. Now we can not only feel the stone, but we can also see it. This possibility seemed to have settled all diagnostic questions at once. But important as the method is, sometimes it fails, as more thorough observation has shown us. It is true, in the great majority of cases, the cystoscope furnishes the most precise information as to the size and shape of a calculus. Besides the question of whether it be movable, free or encysted, whether there is more than one calculus and how many, and, as a rule, whether the functional disturbance, the pain and the occasional hemorrhage was not due to the presence of a tumor, can be proved. Still, as I have emphasized repeatedly in previous publications, this most useful instrument may fail when a calculus is encysted. In fact, the stone may be so deeply imbedded in a diverticulum, from which it fails to project, that its area does not present any essential changes to the cystoscopic view.

Therefore cystoscopy, valuable as it is in itself, should always be aided by the Roentgen method, thus rendering the overlooking of a buried calculus a simple impossibility. On the other hand, the most positive Roentgen picture should not be the only guide for the operative strategy, a cystoscopic examination being necessary besides. Never before did the association of these two methods appear so important to me as in a recent case. in which the Roentgen method seemed to contradict the findings of the cystoscope.

The patient, a man of 63 years, was first examined by me March 30, 1907. Six months before that date he began to suffer from frequent and sometimes painful micturition. The urine was bloody at times. During the last two months the painful micturition had increased, especially after bodily exertion, and the signs

of decomposition of urine were marked, the general condition also becoming more and more impaired. The presence of a vesical calculus was thought of, but the introduction of a metal catheter by the family physician did not produce a click. The patient was referred to a surgeon, well trained in cystoscopy then, whose diagnosis was tumor of the bladder.

When I introduced my stone searcher I perceived a feeling of resistence similar to that sometimes noticed in hypertrophy of the prostate. Rectal palpation revealed marked hardness in the continuation of the prostate, slightly toward the left. Cystoscopic examination showed the presence of an oval tumor, with a nodular surface, and of the size of a hen's egg. Microscopic examination of the urine revealed the signs of purulent cystitis besides the presence of epithelial cells with an excess of cystin.

The Roentgen picture presented a regular elliptic shadow in proportion to the size of tumor seen by the by the cystoscope. (The filograph could not be well reproduced on paper, wherefore it is omitted). Especially the regularity of the outlines of the shadow were identical with the shape found in calculi of fairly large size. The polymorphous epithelial cells not giving any special diagnostic information, I was tempted to assume that I had to deal with an encysted calculus. But suprapubic cystotomy performed April 2, 1907, showed the presence of a hard carcinomatous tumor, the broad base of which began at the left side of the trigonum. The whole mass was interspersed with crumbs of calcareous masses, which appeared like a skeleton surrounded by shreds of fibrous tissue. The microscopic examination, for which I am indebted to Professor Buxton, showed the calcareous matter to consist of phosphates, while the tumor tissue was fibrocarcinomatous. The renal regions gave a negative skiagram. The patient made a good recovery, but two

months later the signs of recurrence became apparent and shortly thereafter the patient died from pyelonephritis. In this case the Roentgen method, otherwise so ready to enlighten us, was apt to obscure the nature of the case, which the cystoscope had recognized in its true character at the very beginning. While it undoubtedly occurs not too rarely that calculus gives the impetus to carcinoma-formation, in this instance carcinoma was the primary lesion, the incrustations being deposited while the carcinoma was growing. The large amount of the calcareous matter was remarkable. I believe it to be worth while for physicians to give these points their attention in order to clear them up further. So far the literature does not mention them.

A NEW AND RAPID METHOD OF PERINEAL DRAINAGE IN SUPRAPUBIC PROSTATECTOMY.

JOSEPH RANSOHOFF, M.D., F.R.C.S.
CINCINNATI.

The question of choice of route in operations on the bladder is not a new one. Since bladder stones were first removed by operation, the question between the sectio alta and sectio perinealis has been the subject for heated discussion among surgeons. The radical treatment of prostatic enlargement by operation has given it a new interest. Since the perfecting of suprapubic prostatectomy by Fuller, Freyer, Fenwick and others, its adoption by surgeons in general has been very large. On the other hand, the advocates of the perineal route by the methods of Parker Syms, Proust and Young are no less staunch, though perhaps fewer in number.

Each method has its advantages and disadvantages. To my mind, and from an experience not inconsiderable with both methods, the advantages of the suprapubic method largely outnumber those of the perineal operation. When it is indicated, it can, save in exceptional cases, be completed in less than fifteen minutes. When we consider the advanced age and the debilitated condition of most prostatic sufferers, this of itself is of prime importance. The suprapubic operation does not disturb the normal relations of the perineal pockets, and what hemorrhage there is before reaching the prostate comes from the bladder wall, where it is easily controlled. The hemorrhage incident to the enucleation of the prostate

is always easily checked, if the incision in the bladder is of adequate length. Here I have found the use of formaldehyd-gelatin (glutol) of inestimable service.

Through the suprapubic incision the prostate can easily be enucleated as a whole, the finger of the left hand (properly protected with gloves) forcing the gland from the rectum toward the enucleating finger. If a conservative operation is to be performed, which I regard in the average cases as a mistake, the removal of the middle lobe or bar and parts of the lateral lobes with the retention of the seminal bridge is thoroughly feasible. Wounding of the rectum in capable hands is an accident almost impossible; while in the perineal route I believe it to be a not infrequent complication, even in master hands. Postoperative sloughing of the rectum can only occur after a perineal operation.

WHEN THE PERINEAL ROUTE IS PREFERABLE.

There is, of course, one class of cases in which the perineal operation is always indicated. I refer to the small, dense fibrous prostate, adherent to the capsule, and in which a cystoscopic examination shows little or no intravesical projection. Here the careful dissection necessary to removal must be made with cutting instruments, and should, therefore, be controlled by the eye of the operator. In that very rare class of cases of prostatic hypertrophy in which there is concentric hypertrophy and contraction of the bladder, the perineal route is also to be preferred.

A comparison of the mortality statistics of the two methods of prostatectomy militates somewhat against the high operation. For this a number of factors are responsible. First, it doubtless is true that the high operation is reserved by many for the more advanced cases and those complicated, as for example, with stone. The second and more important cause for the greater mortality of high prostatectomy lies in the inadequacy of drainage as it is commonly sought to be established in

violation of a fundamental principle of wound treatment. Uphill drainage is the one generally practiced after high cystotomy.

INFECTION OF THE PREVESICAL SPACE.

Since an overwhelming majority of patients requiring an operation on the prostate present an infected bladder, the results of the suprapubic operations are vitiated by the not infrequent infection of the prevesical space, and sloughing of its loose connective tissue. At best the wound is kept clean with difficulty, all mechanical devices to the contrary notwithstanding. Frequent changes of dressing are imperative and become disturbing to the patient. Not infrequently canvalescence is protracted by an annoying eczema around the wound. It is not unusual for a vesical fistula to persist for months, and in some cases it is permanent. Added to these disadvantages is the necessity of long confinement in bed with all its attendant menaces.

The danger of a ventral hernia I believe to be largely overrated. I have seen it in only one case. In this the incision was a transverse one. To gain sufficient room the rectus was partly divided on each side.

To obviate the difficulty of draining the prevesical space, drainage may be secured by a catheter retained within the entire length of the urethra, or by a second perineal, median section (boutonnière operation). Drainage through the entire length of the urethra by a retained catheter has, in my hands, proved unsatisfactory. The caliber of the largest tube the anterior urethra will tolerate is, in my experience, not large enough for adequate drainage. The ordinary catheter easily becomes clogged by small blood clots and thereby defeats its own purpose. Furthermore, the discomfort of a prolonged retention of a catheter within the urethra is not to be disregarded.

The alternative is perineal section and drainage. While it is true that the ordinary boutonnière opera-

tion may be quickly done, it necessitates placing the patient in the lithotomy position after the prostatectomy has been completed. In this operation, as in perineal prostatectomy, there is danger of wounding the bulb

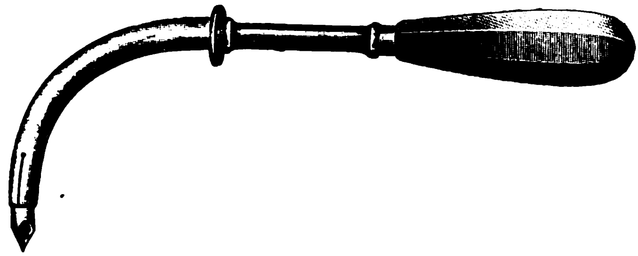

Fig. 1.—Trocar for opening the perineum after shelling out the prostate.

and of opening the superficial perineal pocket. Post-operative hemorrhage into the scrotum and sloughing with all its attendant dangers, and protracted confinement in bed, can not be uniformly avoided. The divi-

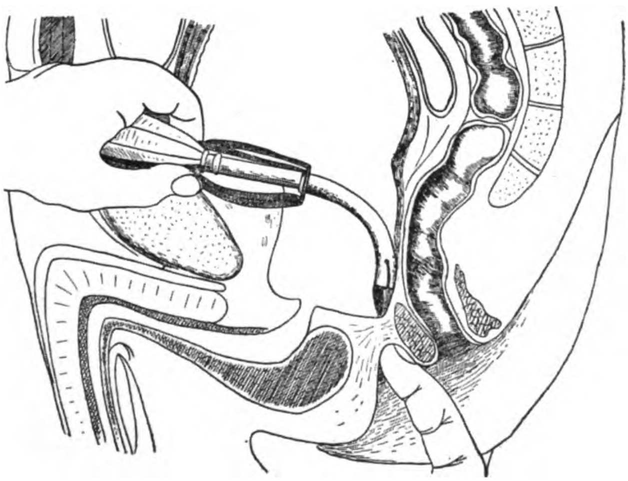

Fig. 2.—Trocar pushed through the most dependent part of the emptied prostatic pouch against a finger of the left hand placed a little in front of the anus. Bulb avoided and membranous urethra undisturbed.

sion of the cut-off muscle incident to the median section for drainage can not but seriously retard the patient's control of urine.

For these reasons, within the past eight months, after shelling out the prostate through an adequate suprapubic section, and after controlling hemorrhage, I have, so far as possible, opened the perineum from above by a large trocar and cannula (Fig. 1). The trocar is pushed through the most dependent part of the emptied prostatic pouch against a finger of the left hand placed a little over half an inch in front of the anus. By backward pressure the finger of the right hand protects the

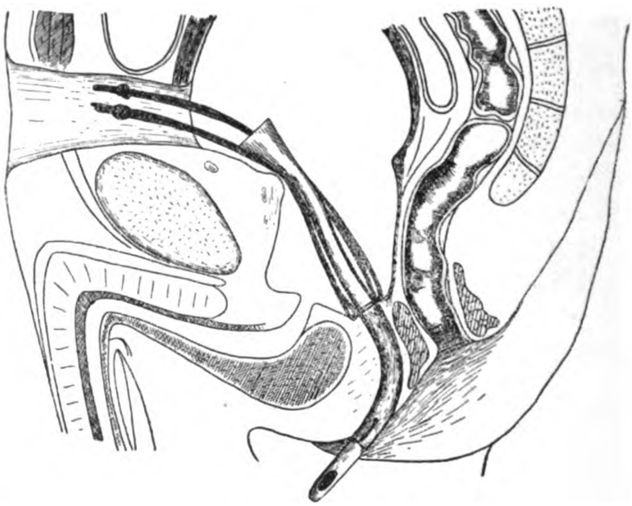

Fig. 3.—Trocar withdrawn and a large self-retaining catheter or drainage tube pushed through the cannula from within. Cannula is then removed through the suprapubic opening by the affixed tape.

rectum. This is easily done without changing the position of the patient. The bulb is avoided and the membranous urethra undisturbed (Fig. 2).

The trocar being then withdrawn, the cannula projecting through the perineum, the largest self-retaining catheter or a drainage tube is pushed through the cannula from within. The cannula is then removed through the suprapubic opening by an affixed tape (Fig. 3). The caliber of the cannula is that of a thirty-six

(French) sound. After the cannula has been withdrawn, the drainage tube is placed with its upper end in the prostatic pouch, where it may be fixed by a perineal stitch (Fig. 4).

This method of establishing perineal drainage takes less time than does its description. The harmlessness of the procedure is a further advantage. There is practically no danger of hemorrhage from the stab made from within, and the pressure of the rubber tube when placed in position is sufficient to arrest what little bleeding might take place. I have never seen infiltration

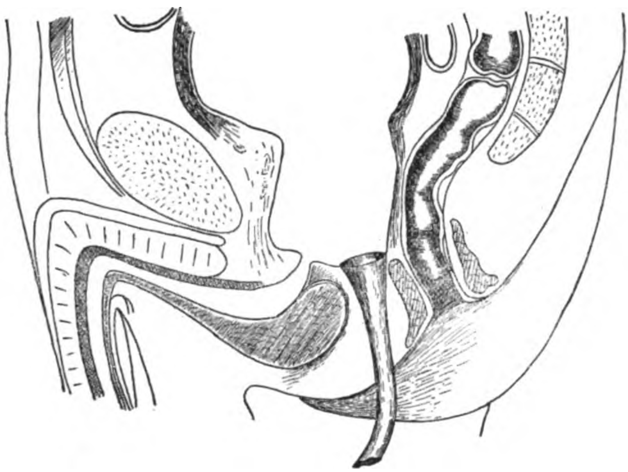

Fig. 4.—Cannula withdrawn and drainage tube placed with its upper end in the prostatic pouch and held in place by a perineal stitch.

of the scrotum by reason of opening the superficial perineal pocket, nor bleeding in any of the twelve cases in which I have resorted to this method of drainage.

I complete my operation by layer suture of the bladder wound. The abdominal wound is also closed by layer sutures, save for a very small cigarette drain placed against the sutured bladder as a matter of security. The after-treatment is precisely like that of perineal prostatectomy and the patient is enabled to be out of bed at the end of a week.

As compared with other methods of securing drainage after suprapubic cystotomy, where drainage is indicated, I believe this method to be possessed of such advantages that I confidently submit it to my colleagues for trial.

DISCUSSION

ON PAPERS BY DRS. BECK AND RANSOHOFF.

DR. HUGH H. YOUNG, Baltimore: Retention of urine is one of the greatest causes of vesical calculi and chronic retention should not be allowed to persist unattended. Infection of the bladder, however, is more often a cause of calculus formation, except in young men in whom the calculus is of the oxalic type. It is possible that in some instances the agglutinating action of bacteria may be responsible for the formation of the nucleus of the calculus.

Every one knows that I am more or less opposed to suprapubic prostatectomy. The perineal operation can be done just as quickly as the suprapubic. I have frequently been able to complete the operation in from twelve to thirteen minutes, and I hold that time is not such a great factor that it is necessary to do a destructive operation in order to get the patient off the table very quickly. As a matter of fact, the operation can be done just as quickly one way as another. The checking of hemorrhage is one of the greatest objections to the suprapubic route. Dr. Ransohoff speaks of the use of gelatin and other things that take a great deal of time. The use of packing in the suprapubic wound, that is in the cavity left after enucleation of the prostate is greatly condemned by Freyer of London, who holds that hot water run through a tube in the perineum is best, and is really the only styptic to be used. His statistics show that there should be left as little place as possible for the collection of fluid or the deposition of pus, and that no packing in the suprapubic wound should be used. If the perineal operation is done carefully injury of the rectum should never occur. In 200 cases I have not, so far as I know, a single case of rectal fistula to answer for. I am glad to see this acknowledgment of the disadvantage of uphill drainage. A suppurating bladder can not be thoroughly drained in that operation. From the anatomic standpoint there are certain things that would keep me from using this very ingenious instrument. I believe that the method of supplying good drainage is good, but the question is whether he has chosen a method that is free from danger. Suppose that after a suprapubic prostatectomy the urethra has been opened and there is a large cavity beneath the urethra from which the prostate has been removed. If the urethra has been removed with the prostate there is another cavity connecting with the bladder. The bulb surrounds the urethra; the perineum comes down and opens into the rectum, and then the rectum takes an acute bend forward

and lies very close to the prostate and membranous urethra. This portion of the rectum has been called by the French the bladder of the rectum; it evidently has the function of holding the feces so that it will not press against the anus. In dissections I have frequently found the rectum drawn out so that it was in absolute contact with the bulb, and in some cases anterior to the bulb, especially in patients who had had a previous perineal section. It is held forward by the rectourethralis muscle, whose object is to preserve this curve of the rectum. Dr. Ransohoff's instrument, as I understand it, is introduced through the inferior part of the incision, and he tried to go posterior to the bulb. I hold that in such cases it would be distinctly dangerous to go from this point to the perineum with the danger of injuring the bulb of the membranous urethra and the sphincter, and in certain cases there would be a great danger of going through the rectum. I feel that the instrument ought never to be used except by Dr. Ransohoff, who understands its uses, its dangers and can avoid them. I think that the mortality is the one thing we bear in mind in choosing a method of prostatectomy. Unquestionably the suprapubic method is excellent in its results and it cures in desperate cases, but it is only by studying a long series of cases that we can determine which operation should be done. My experience in at least 500 cases of enlarged prostate shows conclusively that the perineal method is the simpler and is unquestionably less dangerous. In a period of almost three years I had 128 consecutive cases without a death, and every one of my patients left the hospital alive and well. Among these were 4 over 80 years of age; 23 over 75 and 46 over 70, and during that period of three years I do not think that more than 3 or 4 patients came to the hospital who were not operated on. That may be more or less good luck because since then, in a period of three months, there were three deaths. One of these patients was a severe case of pyonephrosis and one died in the ninth week after operation.

Dr. Bransford Lewis, St. Louis: The question of diagnosis is the most interesting one we can take up. One certainly can not make a correct diagnosis based on the symptoms, because these will mislead as often as they prove reliable. Five minutes of a physical examination will tell one more than a week's analysis of the symptoms. Which method of physical examination is the most serviceable, the most accurate? We must not exclude any method. Cystoscopy and radiography are both valuable and both should be used. I agree with Dr. Beck in much that he said. First, as to the feature of the searcher. It is a searcher, but it is often not a finder. In many cases of vesical calculus not only did I fail to find the calculus by means of the searcher, but those who preceded me in these cases likewise failed. An old doctor in the West

carried three stones in his bladder for ten years. He was troubled with frequent urination during all this time, but no stones were found until the cystoscope was used. In another case a stone the size of a hen's egg was in the bladder without being detected until the cystoscope was used. The prostate may hide the stone from the searcher and yet it may be as plain to the cystoscope. In relation to ureteral calculus, the same thing holds good. We must use the cystoscope and the ureteral catheter, as well as the *x*-ray in order to exclude certain failures; one or the other method may be useful, but certainly we ought not to limit ourselves to either one or the other; otherwise we may go astray. Dr. Ransohoff's description of the method made a better impression on me than I arrived at *a priori*, and I am favorably impressed with his plan. If that method does succeed, it removes one of the greatest objections to suprapubic prostatectomy, because if we take the two operations, the suprapubic versus the perineal, the execution is probably easier in the former than in the latter; but if we take into consideration the convalescence the perineal is the preferable operation because of the better drainage and the recuperation. If Dr. Ransohoff succeeds in doing away with this slower and more unfavorable convalescence from the suprapubic prostatectomy this will lessen the discomfort from the operation and make it more popular. I have favored perineal prostatectomy because of the better convalescence.

Dr. J. E. Cannaday, Hansford, W. Va.: We must admit that the surgery of the bladder is less perfect than the surgery of other parts of the body, especially of the abdomen. What Dr. Lewis said with regard to the advantage of the suprapubic prostatectomy is true. That operation is easier for the average man to perform; and, again, the results are far better because the surgeon is not so apt to have the troubles of urinary incontinence and perineal fistula, which sometimes give a great deal of trouble to the men who are not very familiar with this class of work. Of course, in the hands of some experts better results follow from the perineal operation than from the suprapubic. When one drains the bladder one gets a fluid that is not only toxic but is also often infected, and unless this fluid is all drained away infection of a large raw area and absorption from it will result. If after a suprapubic operation one drains from below, he gets the advantages of both operations.

Dr. J. Ransohoff, Cincinnati: I have tried this method in twelve cases; in none did I hurt the rectum. I know that one can not take out a prostate entirely without damaging the urethra to a considerable extent, and, therefore, the objection made to this method of drainage, namely, that the pocket is left with an intact channel running through it, is, I think, entirely theoretical. The other objection to the method is on

the anatomic grounds that there is only a slight interval between the rectum, on the one hand, and the floor of the urethra on the other. In the ordinary buttonhole operation, the old median operation for stone, this interval was utilized. The older surgeons who were fully familiar with the surgical anatomy of this part favored it, and it has been done for at least 2,000 years. It was always done, if possible, behind the bulb. The bulb was guarded, the rectum was pushed back with the finger, the membranous urethra was opened and through it the finger was introduced into the bladder. A wounding of the rectum in this operation was considered almost a disgrace. In the operation I have described and practiced a little judgment is necessary. It is the easiest thing in the world with the finger in pocket emptied of the prostate to push the rectum out of the way and the trocar to the perineum and pierce the intervening soft parts. The rectum is not endangered because it is kept out of the way. I know that Dr. Young prefers the perineal operation. I do perineal prostatectomies often and I prefer that method almost always when the upper end of the prostate can be reached through the rectum. I have only advised my method as a slight improvement in the technic of suprapubic cystotomy. The great difficulty of preventing infection of the prevesical spaces and that of infiltration of blood in the superficial perineal pocket with its attendant dangers by my method I try to abort. This method of stab puncture endangers neither the bulb nor the rectum. I may be permitted to add that in one case at least the patient after the operation enjoyed the pleasures of paternity, and I think I can state, as did Gil Blas at the end of his many adventures, that "this man has a son of whom he conscientiously believes that he is the father."

Dr. Carl Beck, New York: It is remarkable how skilful some men may be in most respects and yet how unskilful in handling an *x*-ray machine. There is not a vesical or renal calculus which can not be shown on a skiagraphic plate. If it is in the kidney or bladder and it is not demonstrated by the skiagrapher, it is the fault of the man and not of the method.

I wish to modify my views somewhat by adding that there is no reason why every man who handles an *x*-ray machine should always be successful. He may be successful to-day and not to-morrow. I have had large experience with this special work, and yet I make many poor pictures. There are sometimes little details which we do not have in mind at the time, and these might not be observed, and that is the reason why we get a poor picture. In that case, however, one must recognize that it is a poor picture and not try to tax all the powers of the imagination to find what is not shown. We must not guess. We must see and have the undeniable presence of the stone.

THE SURGICAL IMPORTANCE OF CERVICAL RIBS TO THE GENERAL PRACTITIONER.

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I should scarcely venture to present this topic here, were it not that the general medical profession has not yet become familiar with it. Surgeons and neurologists have in recent years awakened to the great value of studies in embryology, comparative anatomy and pathology. The results of such studies are, however, more or less unknown to the bulk of practitioners, because they are published chiefly in journals devoted to the specialties of medical science. The surgical importance of vestigial structures, like the omphalomesenteric duct, the thyroglossal duct and the branchial clefts, and the relations of bony and other structural anomalies have a place, therefore, in the discussions of this Section.

A few years ago a distinguished surgeon remarked in a formal address that accurate anatomic knowledge was now hardly an essential in the training of a surgeon. Such an opinion is invalidated by a brief reference to the development of the surgery of cervical ribs. Most of us who spent the early days of our training in dissecting room study and teaching have been familiar with skeletal anomalies found in the vertebral column and ribs. Lumbar ribs, cervical ribs and supernumerary vertebræ are recognized as occasional evidences of the relation of the human vertebrate to other animals possessed of a back bone. The anterior tubercle on the

transverse process of the cervical vertebra of man has long been known to represent the cervical ribs of certain vertebrates. In my own case such topics interested me so much that my graduation thesis was entitled "The Mechanical Construction of the Spinal Column."

Notwithstanding the recognized occasional occurrence of cervical ribs in man, Coote[1] reported in 1861 a successful operation for the removal of "an exostosis of the left transverse process of the seventh cervical vertebra, surrounded by blood vessels and nerves." In his article he refers to a case of supernumerary rib without symptoms reported by Willshire[2] the year before. He describes his own case as an exostosis, although he attributes the bony process to a development of the costal element or rib of the seventh cervical vertebra.

Another interesting illustration of our failure to appreciate the relations of facts is that given by H. Lewis Jones.[3] In 1893 he published[4] a short paper on "Symmetrical Atrophy Affecting the Hands in Young People," recording six instances of the disease, the cause of which he was unable to explain. In 1902 Buzzard[5] showed that these cases should be regarded as due to a lesion of the first dorsal nerve root. Notwithstanding the study given the affection by these neurologists, it was not until 1904 that it was suggested by Thorburn[6] that the palsy and atrophy of the intrinsic muscles of the hand in such patients was caused by pressure from a cervical rib. Jones then searched for and found a number of the patients previously described and proved the existence of the unsuspected cervical rib by *x*-ray examination. These historical allusions show how little appreciation surgeons and neurologists had until recently

1. Lancet, April 13, 1861, p. 360.
2. Lancet, 1860, ii, p. 633.
3. Cervical Ribs and their Relation to Atrophy of the Intrinsic Muscles of the Hand, Quart. Jour. Med., January, 1908, p. 187.
4. St. Bartholomew Hos. Rep., 1893, p. 308.
5. Uniradicular Palsies of the Brachial Plexus, Brain, London, 1902, xxv, 209.
6. Med. Chir. Tr., 1905, lxviii, 109.

of the importance of the anomalous cervical rib as an etiologic factor in vascular and nervous lesions of the neck and upper extremity.[7]

AN ILLUSTRATIVE CASE.

History.—A few months ago a woman, aged 32, applied to me for surgical advice regarding a supposed aneurism at the base of the neck on the right side. She had observed a swelling there when a young girl, but had given no special attention to it, because it caused no inconvenience. About ten years ago she had called the attention of a medical man to the existence of this swelling, and an *x*-ray examination was made. No diagnosis was given her, however, and she apparently allowed the decision to remain undetermined. About four months prior to her consultation with me she became annoyed at the existence of the swelling and pulsation at the base of the neck and consulted a local physician. He suggested the possibility of aneurism or some disease of the blood vessels and considered a surgical opinion desirable.

Examination.—I found the subclavian artery higher than usual and very visible as a pulsating vessel under the integument. There was no change in radical pulse, and no numbness, coldness, anemia, or pain in the arm, hand or fingers. The right hand showed no atrophy or paresis. The patient

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7. For those who may care to look further into the historical phase of the subject, the following additional references are given:
Williams: Ann. Surg., October, 1898, p. 512.
Lloyd: Ann. Surg., October, 1898, 513.
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v. Rutkowski: Ztschr. f. klin. Med., 1906, ix., 267.
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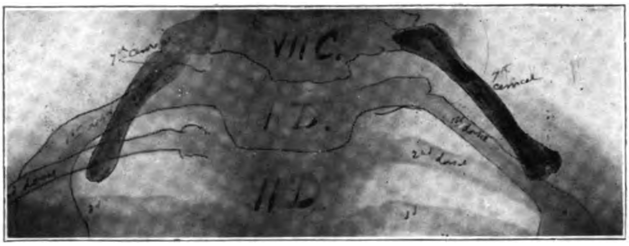

Fig. 1.—Skiagram of Dr. Roberts's cases of bilateral seventh cervical rib. The shadows of the cervical ribs were "inked in" before the reproduction was made. The outlines of the first and second dorsal have been marked with ink.

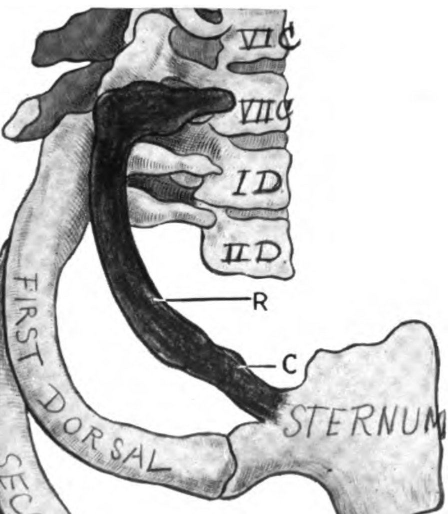

Fig. 2.—[From Hunauld.] Showing seventh cervical rib (R) and its cartilage (C).

suffered no pain in the neck. Palpation disclosed a cervical rib on both sides. The diagnosis was confirmed by an *x*-ray plate. (Fig. 1.) As the patient suffered no inconvenience other than that caused by anxiety regarding the nature of the pulsating swelling I advised that no surgical or medical treatment be adopted.

This case is on a line with those just mentioned; which show that cervical ribs deserve serious consideration as a possible cause of a number of vascular and nervous symptoms pertaining to the neck and upper extremity.

The correlation of exact biologic knowledge with the practice of medicine has been quite characteristic of the last fifteen years. Such investigations, combined with the use of the *x*-ray in diagnosis, have shown that cervical ribs are not uncommon in the human skeleton. It therefore behooves physicians, surgeons and specialists always to recall that pain, anesthesia, muscular spasm, defective circulation, or atrophy in arm or hand may be due to pressure, in the supraclavicular triangle of the neck, from increase in size or a change in relative position of an anomalous rib connected with the seventh or the sixth cervical vertebra. Supposed bony tumors in this part of the neck may be the rib itself or an outgrowth from it.

Other anomalies require like attention on the part of practitioners. One need only mention lumbar ribs, fused long bones, ossa triquetra, sesamoid bones, ossific plates in the pelvic ligaments, supernumerary digits, accessory thyroid and mammary glands, double arteries, multiple ureters, aberrant kidneys, and other anatomic variations to enforce the opinion that successful operative surgery needs the aid of morphology and descriptive anatomy.

VARIOUS FORMS OF CERVICAL RIB.

The usual cervical rib is attached to the transverse process and perhaps the body of the seventh cervical vertebra (Fig. 2) and may be found on both sides of

the neck. When the condition is bilateral, one rib is frequently longer and better developed than the other. Occasionally both the sixth and seventh vertebræ are furnished with these irregularly shaped costal appendages. A cervical rib generally approaches in some degree the outline of a dorsal rib. Its attachment to the spinal column, if it be so attached, is also like that of dorsal ribs. It is, however, quite often a very distorted representation of a rib. Its anterior end may be attached to the sternum (Fig. 2), may articulate with the upper surface of the first dorsal rib (Fig. 3), or may lie in the soft tissues without any other osseous connection than that which it has with the spine (Fig. 4).

Sometimes the middle of the rib is a fibrous cord uniting a posterior, or vertebral, bony segment with an anterior bony segment, which may be fastened to either the sternum or the first dorsal rib. In other cases there may be a posterior and an anterior bony segment with no intervening fibrous or bony tissue to represent the shaft or body of the rib. The irregularity of the curves of and the knobs on the anomalous rib may be extreme.

The anomalous rib occupies a position in the neck considerably above the clavicle and broadens the base of the neck. The knobbiness, irregular thickening, or angularity of the rib may make a marked prominence, quite distinctly seen in the supraclavicular triangle, just behind the sternomastoid muscle. The resistance detected by palpation or the discovery of a hard mass or tumor buried in the muscles may lead to a correct diagnosis. If the anomalous rib extends to the sternum or is attached to the first dorsal rib near the sternum, the roots of the brachial plexus, the subclavian artery and the subclavian vein may be expected to pass over its superior surface. If the rib is two or three inches long, though incomplete in front, the roots of the plexus and the artery usually cross its upper surface in their

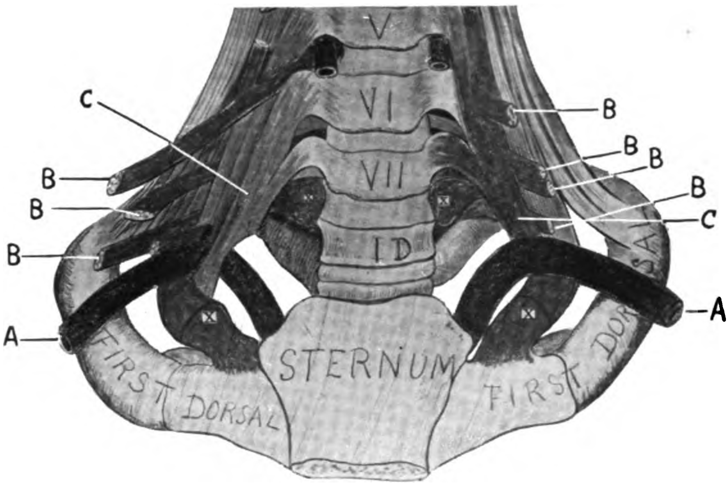

Fig. 3.—X, X, seventh cervical rib; A, subc'avian artery; B, B, cervical nerves; C, anterior scalene muscle. On the left side the artery crosses the cervical rib in *front* of the anterior scalene muscle; on the right side it *perforates* the muscle. These relations are unusual. The nerves perforate the muscle on both sides. [Modified somewhat from Pilling.]

Fig. 4.—U, seventh cervical rib; V, abnormal position of subclavian artery; W indicates normal relation of subclavian artery to first dorsal rib when no cervical rib is present. M, anterior scalene muscle. [Modified somewhat from Keen.]

course to the arm, but the vein does not, because it is situated too far forward (Fig. 5). The anterior scalene muscle is often fastened on the cervical rib (Fig. 3); the middle and posterior scalene muscles are sometimes attached to it. The artery usually lies between the rib and the anterior scalene muscle; that is, behind the muscle (Fig. 4). It may, however, lie in front of the anterior scalene muscle (Fig. 3, one side). In the latter event it is not so likely to suffer pressure from the anomalous rib. This artery may, however, take its course from the thorax to the arm through the space between the cervical rib and the first dorsal; it then has the usual relation to the first dorsal rib. It and the roots of the brachial plexus may pass through clefts in the anterior scalene muscle (Fig. 3, one side). Pancoast says that Turner speaks of a cadaver with bilateral cervical ribs, in which the right subclavian artery arose from the aorta and passed behind the trachea and esophagus to reach the right side of the neck. The eighth cervical and first dorsal nerves, which are the lowest roots or components of the brachial plexus, run, as a rule, across the rib, just behind the artery, and are quite liable to suffer compression.

The subclavius muscle may have an attachment to the cervical rib as well as to the first dorsal rib. The rhomboid ligament may be attached to the cervical rib, if the latter extends far enough forward. Sometimes the space between the cervical and the first dorsal ribs is spanned by fibers of the scalene muscles, representing an intercostal muscle. A perfect sheet of intercostal muscle may be found in this situation.

Cervical ribs are congenital anomalies and have been detected in young children. It is said that the peculiarity has been seen in a six months embryo. The so-called two-headed, or bicipital, ribs described by anatomists are composed of the shafts of two adjacent ribs, which have been congenitally fused. The first

dorsal rib and an anomalous seventh cervical rib sometimes display this error in development. The apex of the pleural sac is not distant from a cervical rib and may be attached to it.

A critical study of the anatomic relations of the condition is scarcely germain to this paper, and I shall therefore now discuss the symptomatology.

SYMPTOMS OF CERVICAL RIB.

Many persons with cervical ribs suffer no discomfort from them; and their existence is unknown unless discovered by some chance clinical investigation. The symptoms are due to pressure on vessels and nerves. The determining cause of the advent of symptoms is obscure. It has been supposed that there is a tendency toward the third decade of life for cervical ribs to grow in length, or to increase in size by the development of exostoses. Those ribs which extend directly outward from the spine appear to cause less trouble than those which project downward and forward. The short stumpy bones (Fig. 6) seem, according to Howell, to produce symptoms more readily than the longer ribs. This is perhaps due to the fact that the more perfect the shape of the rib, the more it and adjacent structures conform to physiologic standards and needs.

Symptoms have developed suddenly in children as well as in adults. A boy of thirteen years, for example, experienced the pressure symptoms first after a long swim. The advent of pain in numerous cases has been attributed to violent exercise or to a blow or injury. It is possible that the nerves have sustained injury by such accidents and therefore first gave the signal for investigating the skeletal details of the region above the clavicle.

The rigidity of increasing age has perhaps an influence, because the soft springy bones, ligaments and cartilages of children and young adults lessen the shock of blows. Cervical ribs are at times slightly movable.

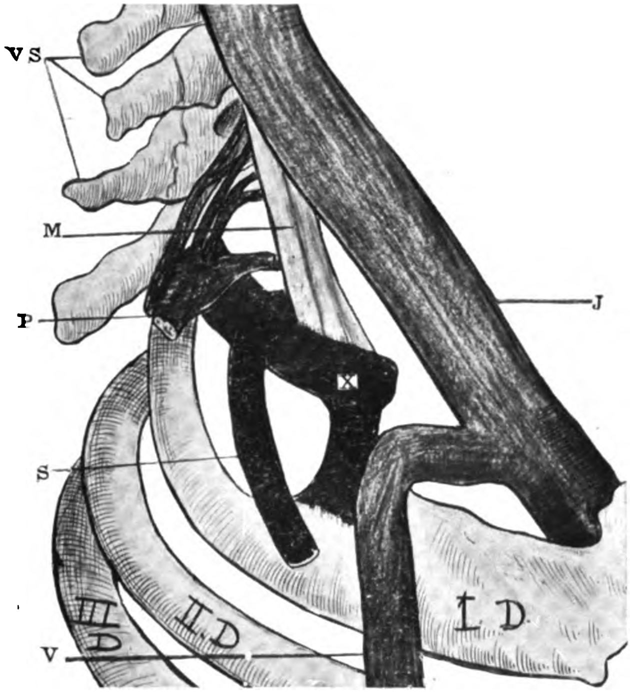

Fig. 5.—X, irregularly shaped cervical rib articulating with first dorsal rib; VS, vertebral spines; S, subclavian artery passing over cervical rib behind anterior scalene muscle; V, subclavian vein; J, jugular vein; P, cervical nerves; M, anterior scalene muscle. [Modified somewhat from Weissenstein.]

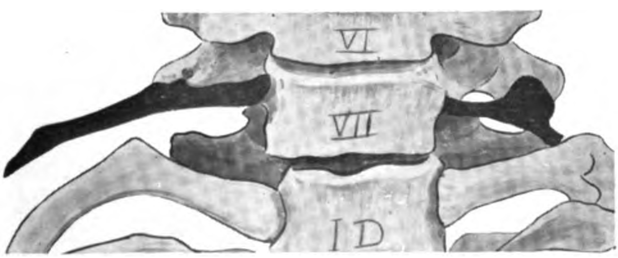

Fig. 6.—Rudimentary cervical ribs are shown in black. They are very dissimilar in shape. [From Howell.]

[illegible]

The symptoms are chiefly those due to pressure interfering with the blood current in the subclavian artery and sometimes in the vein, and those resulting from irritation or inflammation of the last cervical and first dorsal nerves. These nerves enter into the composition of the brachial plexus. The rib itself or a knob-like process or exostosis on it may give the physical signs of a tumor on inspection and palpation. The width of the base of the neck may be increased, especially if cervical ribs exist on both sides. Two cervical ribs (sixth and seventh) on each side—a very rare anomaly—would probably be very conspicuous in this respect. Keen states that the clavicle may be bent or even dislocated by the pressure exerted by the anomalous rib during the growth of the structures of the neck. Scoliosis may be induced, with the convex curve of the spinal column toward the side on which the anomalous rib exists.

The vascular symptoms pertain especially to the arterial circulation. Edema of the arm and hand from pressure on the subclavian vein or lymph vessels is rare. Some writers doubt its occurrence. The high position in the neck of the subclavian artery makes its pulsation visible and the artery easily palpable. The artery sometimes becomes dilated and has a murmur, thereby resembling a fusiform aneurism. It is not a true aneurism, however; and the dilatation is distal to the point of pressure, which is where the artery passes between the cervical rib and the anterior scalene muscle.

Endarteritis, thrombosis and embolism may occur, leading to deficient circulation of the hand and arm. This circulatory disturbance is made evident by local anemia and coldness, and occasionally by gangrene of the finger tips.

Depressing the shoulder may increase the compression on the artery and obliterate a previously feeble radial pulse. Deep inspiration may obliterate the pulse in a similar way and cause disappearance of the arterial murmur. After holding the breath, the murmur may reappear with increased loudness on resumption of respiration. A gradual development of the collateral circulation may take place because of prolonged arterial compression, and a corresponding change in the vascular symptoms result.

The disturbances of innervation of the hand and arm are said to be more frequent than those connected with the blood supply. Sensory symptoms are more evident than motor, though spasm like writer's cramp, inability to extend the elbow, and muscular atrophy from degeneration of nerve supply do occur.

The numbness, formication, tingling, hyperesthesia and other evidences of nerve irritation or inflammation are referred especially to the ulnar side of the forearm. If a greater number of nerve fibers are subjected to pressure, or suffer from its secondary results, this area will be much increased and may involve the whole or nearly the whole of the upper extremity. The shoulder and chest may be the seat of pain. The neuralgic pain may be exceedingly severe; and may be intermittent or continuous. It is not certain that the sympathetic nerve is ever involved. Proptosis, dilated pupil, unilateral sweating and other supposed evidences of pressure on the ganglia of the sympathetic in the neck have been mentioned as possible symptoms due to cervical rib. The muscular symptoms are spasm and atrophy.

A study of the symptomatology reveals the reason for physicians making diagnoses of writer's cramp and palsy, rheumatism, neuralgia, muscular atrophy, aneurism, etc., of unknown origin. The possible existence of cervical ribs beginning to cause pressure symptoms should ever be present in the practitioner's mind. The recollection of this possibility will lead to a correct understanding of many heretofore obscure cases. The *x*-ray makes the diagnosis easy.

TREATMENT.

The treatment is excision of the anomalous cervical rib in all cases of severity. The operation, if done well, is practically free from danger, though it naturally varies in its surgical importance in each case. The entire rib should, as a rule, be removed. Subperiosteal resection is not wise, as a regenerated rib may exert pressure again. Injury to vessels, nerves and pleura is to be deprecated and may usually be avoided by the common expedients available to operators. Pneumothorax, local and general palsy of the extremity and troublesome bleeding have been caused in some operations. These mishaps are unusual.

The palliative treatment in mild cases consists in rest of the arm, suspension of the patient, local counterirritation, liniments and massage. The constant electrical current (8 to 10 milliamperes) may be employed, with the anode used as the active electrode. The combined faradic and galvanic current may be found useful.

DISCUSSION.

DR. J. CLARK STEWART, Minneapolis: The advantage of such papers as this is that they familiarize the profession with a clinical entity, which, while it may be rare, is of the greatest importance, especially from a diagnostic standpoint. No one can make a diagnosis of a condition with which he is absolutely unfamiliar. A study of the subject shows that cervical ribs are very common, probably very much more so than even a study of the literature would show, because the condition has hitherto been so seldom recognized.

Cervical ribs which cause symptoms are rare, but it is imperative that if the signs of the condition which Dr. Roberts has so briefly gone over are to be recognized and treated everyone should recognize the possibility of this condition causing these symptoms. I think that the great bulk of these cases which are noted and described have been discovered on account of the deformity, the broadening of the lower part of the neck on one side, accompanied by an elevation of the scapula on that side. The *x*-ray, of course, demonstrates the character of these ribs. The lesson to be learned from the paper is the necessity for careful examination of every case of brachial neuralgia, whether accompanied by atrophy of the muscles or not. Every such case should be submitted to *x*-ray examination, and in a number of cases you will be rewarded by finding an extra cervical rib. Of course, its surgical removal is indicated.

GAS CYSTS OF THE INTESTINE.

J. M. T. FINNEY, M.D.
BALTIMORE.

THE AUTHOR'S CASE.

Patient.—The subject of this paper is a man, aged 60 years, a resident of Illinois, who was referred to me by his son, a physician. He entered the Union Protestant Infirmary on Nov. 28, 1907, with a diagnosis of cancer of the stomach.

History.—His history in brief was that he had always been a man who had enjoyed remarkable health up to about eighteen months ago when he began to have symptoms of indigestion. At that time he weighed something over three hundred pounds, had an excellent appetite and had always been a very hearty eater. During his illness, he had lost almost one-half of his body weight, and at the time he entered the hospital, he was emaciated and cachectic to a marked degree.

Examination.—This was negative except as referred to the abdomen. Here a mass in the region of the pylorus could be both seen and felt. It was hard and nodular. The stomach was enormously dilated, and contained the remains of food eaten several days previously. Examination of the stomach contents was typical of carcinoma, which his whole appearance strongly suggested. It was decided to perform a gastroenterostomy in the hope of giving him temporary relief. His very weak condition rendered doubtful the outcome of any operative procedure. A very unfavorable prognosis was therefore given.

Operation.—Dec. 4, 1907, under ether anesthesia, an incision was made through the right rectus muscle. A carcinomatous mass the size of an orange was found, involving the whole pyloric one-third of the stomach. Nodules of various sizes were found in the liver. The retroperitoneal lymph glands were enlarged and invaded by the carcinomatous process. A no-loop posterior gastroenterostomy was performed. Before closing the abdomen, the hand was passed into the pelvis, as a matter of routine. A curious, soft multilocular cystic tumor, 15

cm. (6 in.) long by 8 cm. (3¼ in.) wide at its widest point, was found attached to the free border of a loop of ileum about one foot above the ileocecal valve. No similar growths were observed elsewhere in the abdomen. From the peculiar cystic appearance of the mass, it was for a moment thought to be a beginning echinococcus cyst. On further examination, however, it was discovered that the cysts contained only gas. The cysts, of which there were a great many, were massed together like soap bubbles, in a basin of suds, being irregular in shape on account of the pressure of the neighboring cysts. The cysts themselves varied in size from microscopic, to as large as grapes. Each cyst seemed to have a thin, fibrous tissue wall of its own. Here and there hemorrhages could be seen in the fibrous tissue stroma. When the cyst walls were punctured, the air escaped with an audible hiss or pop, showing that it was under considerable pressure. The cystic growth was most prominent on the free border of the intestine, but completely surrounded the affected loop, extending here and there in scattered groups on both sides of the mesentery, for a distance of from 2 to 3 cm. (¾ to 1¼ in.) from its intestinal attachment. Some of the cysts were pedunculated. A single cyst or group of them might be attached by a single pedicle. The whole tumor mass was covered here and there by a thin, web-like fibrous structure which suggested an old fibrinous peritoneal exudate that had become partially organized. There were no adhesions between the tumor and the surrounding structures. Portions of the mass were removed for further examination.

The condition of the patient was so critical that excision of the affected loop of the intestine was not to be considered, indeed, it did not appear to be indicated. I cannot report, therefore, as to the mucous surface of the intestine, but there was no evidence that the lumen of the bowel had been at all encroached on. The patient rallied unexpectedly well from the operation. He made an uneventful recovery, and at the time he left the hospital, was gaining weight at the rate of a pound a day. Up to the last report he has continued in excellent health.

On again going carefully over the clinical history of the patient after the operation, there were no symptoms which could in any way be referred to this peculiar cystic growth of the intestine. His history had from the beginning suggested cancer of the pylorus, and the findings at the operation fully corroborated this diagnosis.

The discovery of the gaseous tumor was purely accidental. The tumor itself, however, presents so many interesting features that it seems worthy of being made the subject of a full report.

HISTORICAL CONSIDERATIONS.

On looking up the record of similar growths, I have been unable to find any mention whatsoever of this tumor or anything that suggests it in the medical literature of this country. I believe, then, that this tumor is a unique specimen so far as America is concerned.

The first mention of the condition that I can find anywhere was in 1876, when Bang[1] reported an undoubted case. Following this report, Dr. B. M. Bernheim, whom I have to thank for valuable assistance in the preparation of this paper, has been able to collect from the literature reports of seventeen additional cases, making nineteen in all, up to and including my own case.

The chief interest in this peculiar growth lies in its etiology, and in the presence of circumscribed collections of gas in the tissues of the intestinal walls. It must be said at the outset that at the present time the specific etiologic factor or factors concerned in its production remain for the present undetermined. Light, however, may come from the direction of comparative pathology through the study of the same or a very similar growth which has been observed with considerable frequency in pigs and sheep, notably the former. Mayer[2] of Bonn was probably the first to call attention to the occurrence of cysts containing air in the intestine of pigs. Since then it has been repeatedly observed in the intestine of apparently otherwise healthy pigs, and among veterinarians has been known as "emphysema bullosum."

In medical literature it has been described under a number of different names, of which "Pneumatosis

1. Luftholdige Kyster i. vaggen af aleum og. i. nydannet Bindevav pa sammes serosa. Nod. med. Ark., 1876, viii, No. 18.
2. Jour. prakt. Heilk., 1825.

Cystoides Intestinorum Hominis" (Mayer) or "Gas Cysts of the Intestines" are perhaps the most satisfactory.

It is perhaps a matter of no little interest that this condition was described independently by John Hunter, and two specimens of the tumor taken by him from the intestine of the pig are preserved in the Museum of the Royal College of Surgeons. One of them is thus described: "A portion of the rectum of the hog of which the peritoneal coat is in many places, especially by the side of the mesorectum, covered by groups of thin-walled transparent membranous cysts, attached by pedicles, or having broader bases and containing air."

This specimen was referred to Hunter by Jenner and is described by him in the following words which give Hunter's ideas as to a possible explanation of the condition:

> That air is either formed from the blood or let loose by some action of the vessels both naturally and from disease, is an undeniable fact. We find air formed in fishes to answer natural purposes, for in those whose air bladders do not communicate externally (many of which there are) we must suppose it to have formed there. We also find it in animals after death, and I have a piece of the intestine of the hog which has a number of air bladders in it. Mr. Cavendish was so kind as to examine this air and he found it contained a little fixed air and the remainder not at all inflammable, and almost completely phlogisticated.

A specimen, as Mair[3] well remarks, with the history of which the names of Jenner, Cavendish and Hunter are associated is certainly one of no common interest.

Ostertag, Jaeger,[4] Dupraz[5] and others have described fully these air-containing cysts of the intestine as they are observed in the pig. Dupraz believes them to be a proliferating lymphangitis caused by bacteria, which,

3. Gas-containing Cysts or Air-bladder Tumors, Med. Chronicle, March, 1908, 422.

4. Archiv. f. wissensch. u. prakt. Tierheilk., 1906, xxxii, 4, 5.

5. Arch. de méd. expér. et d'anat. path., ix; Revue méd. de la Suisse Romande; Congr. internat. de gynéc. à Geneve, 1897.

by their ability to produce gas, cause the formation of gas cysts in the course of the lymphatics. This organism he called *Coccus Liquefaciens,* but the only proof he brings forward to substantiate his theory is that following subcutaneous injection of this organism into dogs and guinea-pigs, a resulting gas formation was observed. Numerous ecchymoses and erosions were produced in the mucosa of the intestine, which he considered as portals of entry for the organism. His experiments, however, were neither exact enough nor sufficiently numerous to be convincing or conclusive. Probably the best article dealing with the occurrence of this affection in animals is that by Jaeger which appeared in 1906. He discusses two main theories as to the etiology of the affection: 1. That the gas-containing cysts are caused by bacteria, and 2, that they are caused by purely mechanical and physical conditions. After reviewing Dupraz's work, he discusses the mechanical view as to the origin of these cysts. This is based on the claim that the gas in the cysts is composed mainly of oxygen, and that as yet no micro-organism has been found which produces oxygen, hence there can be no bacterial origin for the cysts. The advocates of this theory have thought that through the stagnation of the intestinal contents and the consequent gas formation, a number of slight abrasions have occurred in the mucosa through which the gas escaped into the tissues. Jaeger insists that the reason the gas in the cysts has always been found to be about the same as atmospheric air is that so much time has always elapsed between the time of the removal of the cysts from the body and that of the collecting and analysing the gaseous contents, that a two-way interchange has taken place between the external air and the cysts, through the cyst walls. The diffusibility of gases through animal tissues has long been known. Jaeger proved it to be true for the intestine of pigs; even such a short time as one hour making a considerable difference in the gaseous content of a loop of intestine filled with

CO_2, O, H and N left suspended in the air. In three hours the H and CO_2 had completely escaped, and the portions of O and N were about the same as in the atmospheric air.

In four cases of gas cysts of the intestine of the pig studied by Jaeger, he found a bacillus of the colon family which produced gas in gelatine culture, which had no odor and was composed of 15 per cent. CO_2, 5.6 per cent. O, 77.3 per cent. H and 6.1 per cent. N. Jaeger followed up his observation by a number of injections of this bacillus into the intestinal walls of animals. Death followed in twenty-four hours by general infection, when there were found in all the layers of the gut a number of very small gas cysts. He called his organism *Bacterium Coli Lymphaticum Aërogenes.* Jaeger's work, while most interesting and suggestive, is rather disappointing in that his animals died so promptly that the typical pathologic picture seen by other observers was not obtained in his experiments. It is only fair to add, however, that he explains this by saying that the disease in his experimental cases ran too acute a course to develop the picture of chronic pathologic changes noted in the other instances, namely, the giant cell formation, fibrous tissue, etc.

While this condition, as has been before mentioned, is observed with more or less frequency in the intestine of apparently otherwise healthy pigs, and is of no special economic value, still it is a matter of enough importance to have attracted the attention of the Bureau of Animal Industry of the Department of Agriculture in Washington. Dr. J. R. Mohler, chief of the pathologic division of this bureau, in a personal communication, writes me the following:

> The study of this quite common affection of hogs was taken up by the pathologic division during the past year in order to establish the cause of this peculiar condition, and if possible to confirm the work of Jaeger. While the affection is not of great importance from an economic standpoint, its occur-

rence in apparently healthy hogs, and the extensive cystic formations in the intestinal walls and on the mesentery, make it of great interest from a meat inspection standpoint. Numerous fresh specimens were received from several abattoirs, from which various culture media were inoculated. The pathologic histology was also carefully studied. A micro-organism belonging to the colon group was obtained from every case examined, and was found to be the etiologic factor of this process. The affection invariably restricts itself to the small intestine, and takes its origin in the mucous membranes. The cysts are always found in the course of the lymphatics, and there is a close association between these cysts and the lymph vessels. Histologically, the lymphatics principally manifest marked changes, and the picture is very striking. Masses of giant cells are found frequently obstructing the entire lymph vessel, and again they may form a uniform lining of the gas cysts. Their presence excludes the theory that the affection is of an acute character, and on the contrary, is indicative of a chronic condition. The experiments are still in progress and attempts to transmit the condition by the introduction of the isolated organism in various ways have not yet been concluded.

Although the experimental work just referred to has to do entirely with the appearance of gas-containing cysts of the intestine of the pig, in all probability it has a direct bearing on the condition as seen in man, and furthermore, while this communication has to do only with the occurrence of gas cysts in the intestine, still it might be well to call attention to the fact that for many years gas cysts have been known to exist in other portions of the body, particularly in the vagina and bladder of pregnant women. As early as 1899, Hahn,[6] in reporting his case of gas cysts of the human intestine, collected thirty-two observations on human beings, nearly all of them in the vagina and bladder of pregnant women. It appears mostly toward the end of pregnancy and usually disappears soon after delivery. It manifests itself in the appearance of numerous small dense cysts filled with gas and scattered over the vaginal surface.

6. Ueber Pneumatosis cystoides intestinorum hominis und einen durch Laparotomie behandelten Fall, Deutsch. med. Wchnschr., 1899, xxv.

Anyone interested in the different views as to the origin of these cysts and their clinical histologic characteristics we would refer to the monographs of Winckel,[7] Eppinger,[8] Schroeder,[9] Zweifel,[10] Chiari, Briesky and Kummel,[13] where they will find the subject fully treated, together with a complete bibliography.

Whether these two conditions are identical or even closely associated can not now be determined, but it is an interesting fact that in Eisenlohr's[14] case, gas cysts were found present in both the vagina and intestine.

ETIOLOGY.

In general, the ideas as to the etiology of this peculiar affection may be grouped under three headings: 1, That it is a new growth; 2, that it is of bacterial origin; 3, that the presence of the gas cysts is due entirely to mechanical causes. Among the adherents to the new growth idea may be mentioned especially Bang,[1] who in 1876 reported the first case, Mair[3] and Kouskow.[15] Their ideas as to the pathogenesis of the disease cover practically the whole ground. Thus, Bang[1] considered the cysts to be a new growth which, starting with the lymph cleft containing the giant cell, in turn grew and spread. The cyst was formed by the degeneration of its center, the contents being at first fluid and later on, by means not explained, gas. He considered the possibility of this gas being secreted from the blood, as in the air bladder of fishes, a suggestion which curiously enough had first been made by John Hunter in the case of the pig.

Mair[3] rejects the idea of an inflammatory or infective origin for the growth, as the histologic picture presented

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7. Arch. f. Gynäk. 1871, ii.
8. Ztschr. f. Heilk., Prague, 1880, i.
9. Arch. f. klin. Med., 1874, xiii.
10. Arch. f. Gynäk., 1877, xii; 1881, xviii; 1887, xxi.
13. Virchow's Arch. f. path. Anat., 1888, cxix.
14. Das interstitiel Vaginal-Darm und Blasenemphysem. Zuruck gefuhrt auf gasbildende Bakterien, Beitr. z. path. Anat. u. allg Path., 1888, iii.
15. Gas Cyst of the Intestine, Boln. Gaz. Botkina (Russian), Oct. 7, 1891, 996 and 1029.

differs from that seen in either of these two conditions. He believes the tumor to be a true neoplasm, the cells of which have the power of secreting gas. He cites as analogous the activity manifested by the cells in the alveoli of the lungs in the exchange of gases, as shown by the work of Haldane and Lorraine Smith. In the air bladder of fishes, which he thinks this tumor resembles more than any other normal structure, gases are secreted from the blood. He believes that these gas containing cysts are analogous in structure and formation to the air bladder of fishes, as had already been suggested by Hunter and Bang.

The giant cells, he believes, are formed by division of the nuclei of the fibroblasts. In these, gas bubbles appear, and gas accumulates around them under sufficient pressure to distend the tissues and form the thin-walled cysts observed. Kouskow[15] believes the tumor to be of congenital origin, and that it develops from the fixed elements of the connective tissue.

In favor of the bacterial origin of the disease are to be found Eisenlohr,[14] Hahn,[6] Winands,[16] Jaboulay[17] and others. All of these observers found bacteria in the tissues of the tumor removed, but there seems to be no uniformity in the particular variety of bacteria found. Cocci and bacilli showing different morphologic characteristics have been described by different observers. As against this idea, may be mentioned the fact that no specific organism has been discovered; that several observers have failed (my own case included) to find bacteria at all, in the tissues of the tumor; and the entire absence of any evidence of inflammation. Among those who believe that a mechanical obstruction of some sort is the basis of this trouble may be mentioned Verebély.[18] He consid-

16. Ueber einen Fall von Gascysten in der Darmwand und in peritonitischen Pseudomembrane, Beitr. z. path. Anat. u. allg. Path., 1895, xvii.

17. Lyon Médical, 1901, xcvi, 753.

18. Pneumatosis cystoides intestin. Orvosi Hetil., 1901, xiv.

ered that the gas in the cysts came from the intestines by way of the tuberculous abscesses which were present in his case, in addition, and that the enlargement of the stomach which also was present, was partly responsible. He quotes Schmutzler as advocating the idea that the intestinal gases may penetrate into the subserous tissues when under strong pressure.

Mori[19] at first adhered to the idea of a bacterial origin of the growth, but after operating on the patient a second time on acount of symptoms of intestinal obstruction, he found to his surprise that the cysts had entirely disappeared. On this account he was inclined to the view that the entire condition was due to circulatory disturbances. If these are relieved, as had been done in his case at the first operation, he believes the condition can be cured.

After carefully studying the conditions as found in my case, which will be presently related, and in the absence of evidence of bacteria either in the tissue or on culture, the most rational explanation of the growth would seem to be that it is a definite entity, a distinct variety of tumor, the cells of which have the faculty of secreting gas. Prof. William H. Welch, who very kindly examined secretions of the tumor, also inclines to this idea. The question as to just what rôle, if any, is played by bacteria in the etiology of this affection will have to be left for the present *sub judice*. Further evidence is necessary to explain conflicting reports. As favoring, however, the idea that the tumor is the result of some obstructive process, circulatory or otherwise, may be mentioned the fact that in practically every case so far reported, this particular tumor has been associated with disease of some portion of the intestinal canal producing a more or less complete obstruction to the lumen of the bowel. The usual form of obstruction has been a con-

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19. Ein Fall von Pneumatosis cystoides intestinorum hominis. Deutsch. Ztschr. f. Chir. ,1907, lxxxviii.

stricting ulcer either active or healed, at the pylorus. In two instances (Mori[19] and Kadyan[20]) the lesion was tuberculous. My case is the first in which the presence of cancer has been noted.

PATHOLOGY.

Of the pathology of the condition, one can not speak very definitely. The histologic findings, however, reported by different observers have presented a strikingly uniform picture. The main characteristics have been a more or less dense fibrous tissue framework, containing many round and spindle cells in various stages of development. In this fibrous tissue mass are to be seen clefts and spaces of varying sizes. These are not uniformly lined with endothelium, but here and there in their walls most observers have reported finding peculiar large giant cells containing many nuclei; as many as fifty to sixty have been reported. In and about these giant cells air spaces have been almost invariably found. Here and there also an apparently definite endothelial lining to the walls of the air cysts has been observed. These tumors as a rule are richly supplied with blood vessels, and some observers have reported the presence of hemorrhages into the tissue. This was quite pronounced in our case. Smooth muscle fiber and elastic tissue have also been reported as present in some cases. Analysis made of the air in the cysts shows it to resemble very closely atmospheric air. The tumor has been observed in all the layers of the intestinal walls. In the majority of instances, perhaps, it is more pronounced in the subserous tissue.

I am indebted to Dr. W. G. MacCallum of the pathologic department of the Johns Hopkins Hospital and to Dr. Charles E. Simon, pathologist to the Union Protestant Infirmary, for an examination of the tissues removed. The substance of their report is as follows:

20. Pneumatosis cystoides intestinorum hominis, Russk. Chir. Arch., 1902, xviii, 1183.

PATHOLOGIC REPORT.

The specimen consists of a mass of rather soft tissue in which there are nummerous cyst-like cavities filled with gas, sometimes under considerable presure. On section, it is found to be composed of a loose fibrous tissue rather richly vascular, and surrounding spaces varying greatly in size, from microscopic to 1.5 cm. (⅝ in.) in diameter. While these spaces are not everywhere lined with endothelium, still here and there can be seen endothelial-like cells which at intervals have formed definite giant cells, containing many nuclei. In one place, in the midst of the fibrous tissue the cells are seen to be greatly swollen and vacuolated, with deeply stained nuclei. It may be questioned whether this is not the point of origin of a new cyst. In many places there are small groups of greatly swollen vacuolated cells in which the protoplasm seems to be blown up by bubbles of gas or globules of fluid. Such groups are usually round or oval. Where they are best developed they have the appearance of a network of protoplasm processes with scattered nuclei. Generally the groups are surrounded by concentrically arranged connective tissue, and in places muscle. Apparently they are really blood vessels. Indeed it is plainly seen in places that not only in cross but in longitudinal sections, blood vessels which show well developed elastic lamellæ are almost or completely occluded by the swelling of the endothelial cells, which balloon out to a great size, the flattened nucleus remaining in the middle. How circulation could have persisted with such extensive obstruction of the vessels is a problem. Not only the endothelium, but also the cells of the adventitia show the swelling or ballooning and there are numerous cells apparently belonging to the connective tissue which are similarly enlarged and filled with great vacuoles. This gives the whole tissue its very loose appearance. There are numerous mast cells scattered about and a few eosinophile cells. In some parts of the tissue there are so many of the vacuolated cells and the tissue is thus rendered so loose and soft looking that it is not difficult to imagine that this might be the method by which the cysts originated, but the nature of this vacuolization is far from clear.

No bacteria were found in the tissues in this case by either Dr. McCallum or Dr. Simon, nor did any growth take place in aërobic or anaërobic culture. The gas contained in the cysts was in such small amount that satisfactory analysis of it was not possible but it was odor-

less and did not burn. Numerous extravasations of blood into the tissues were to be seen.

Clinically, there is no definite characteristic picture that can be recognized, although Hahn[6] states that he believes he could recognize the condition again, and Stori[21] calls attention to a light crepitus which he felt on palpation of the abdomen. Certainly, in the majority of cases there are no symptoms that can be specifically referred to this condition, but in one or two instances (Kadyan[20] and Hahn[6]) it did seem as if the symptoms of abdominal pain and constipation complained of by the patient, could be partially at least accounted for by the presence of the tumor.

DIAGNOSIS.

The diagnosis, then, of this disease, is made usually at operation for some other trouble or at autopsy.

TREATMENT.

Little can be said as to the treatment. The obstructive symptoms if sufficiently pronounced, would require first consideration, but these have been present in very few instances. In the majority of the cases that have been observed during life, it has been overshadowed by some other more important affection, the relief of which has been followed either by improvement or complete disappearance of this tumor. In Kadyan's[20] case, which was associated with tuberculous peritonitis and which necessitated opening the abdomen three times, at the last operation a number of gas cysts still remained, although most of them had disappeared. In Mori's[19] case, at the second operation, which was necessitated by abdominal pain due to adhesions, it was found that the cysts had entirely disappeared.

B. L. F. BANG'S CASE.

Macroscopic Examination.—At the autopsy performed on a woman, aged 57, who had died of volvulus, there were found

21. Contributo allo studio delle cisti gassoso dell, intestino-umano. Clin. Med., Pisa, 1904.

numbers of air-filled cysts covering an area of about two feet of the ileum. They varied in size from a pea to a bean and were mostly in the muscular layer of the gut, which in their neighborhood was very much thickened, sometimes three times that of the normal. The serosa was everywhere covered with an old peritonitic membrane in which, over the affected part of the ileum, numerous air cysts were also found.

Microscopic Examination.—The cysts were lined by an endothelium whose cells were very large, often being thrown up into giant cells of thirty or forty nuclei, having a finely granulated protoplasm. The tissue around the cysts was very rich in dilated blood vessels and lymph vessels, none of which were connected with the cysts. In some of these lymph clefts there were multinucleated giant cells similar to those found in the lining membrane of the large cysts. This was thought to be the earliest stage of the condition, for various grades of it up to the largest cysts were to be seen.

Bang considered the cysts to be a new growth which started with the lymph cleft containing the giant cell, which grew and spread until the cyst was formed by the degeneration of its center, the contents being at first fluid and later on, by a means not explained, gas. He considered the possibility of its being secreted from the blood as in the air-bladders of fish.

WILHELM EISENLOHR'S CASE.

Examination.—At the autopsy, performed on a woman, aged 49, who had died of heart disease, numerous bullet-shaped cysts were found in the bowel wall near the ileocecal valve. Similar cysts were in the anterior wall and labia of the vagina. Those occurring in the intestine were found in the submucosa, muscularis and serosa and reached the size of a pea. Some of them communicated with each other and were connected with the surrounding lymph capillaries, which were very much dilated and had in their walls numerous giant cells which were at times connected with the endothelium. The same condition was present in the large cysts, which were lined with endothelium, the latter not being present in all of them. In some of the cysts, lymph vessels and dilated lymph capillaries, numbers of bacteria were found. They occurred in little granular nests, and only by a magnification of twenty-five hundred could it be seen that they were oval and were

just a little longer than broad. Grouped together, they looked a good deal like the nucleus of a connective tissue cell (possibly they were). In the surrounding tissue there was a small-celled infiltration.

ANTONIO C. DE CAMARGO'S[22] CASE.

Macroscopic Examination.—At autopsy performed twenty-four hours after death on a man, aged 66, who had died of pulmonary tuberculosis, the cecum and ascending colon were found rigidly contracted for 30 cm. (12 in.). The intestinal wall was much thickened, slightly elastic and filled with numerous knobs which consisted of thickly pressed together cysts of different sizes. The contents was gas which had no odor. They were situated in the submucosa and the muscular layer, both of which were considerably hypertrophied, making the gut wall four or five times thicker than the normal.

Microscopic Examination.—The microscope showed that some of the cysts, which were as a rule round, communicated by atrophy of their walls. Sometimes, not always, an endothelial lining of large flat cells could be made out, in which occasionally large giant cells having fifty or more nuclei occurred. No connection could be traced between the surrounding vessels and the cysts. Clumps of small elongated bacteria, sometimes united end-to-end, similar to those found in Eisenlohr's case, were found in the walls and in the lumen of the cysts. No cultures were made.

KOUSKOW'S CASE.

History.—In 1891 a man, aged 57, died after having suffered for a number of years from symptoms of ulcer of the stomach and constipation.

Macroscopic Examination.—At the autopsy three loops of the small intestine were found matted together and involved in a tumor 10 cm. (4 in.) long by 5 cm. (2 in.) wide and 3 cm. (1¼ in.) thick. In addition to this, there were similar smaller tumors on two or three loops a little distance away. The surface of the tumor was translucent everywhere and irregular. Palpation gave the sense of a firm, dense and quite tense membrane, incision of which was followed by a noisy escape of gas showing that this membrane was the outer wall of numerous separate cystic cavities varying in shape and size, the largest being about 6 cm. (2¼ in.) in diameter.

22. Récherches anatomiques sur l'emphysème spontané: Thèse Inaug. Geneva, 1891.

None of these cysts connected with any other, they contained nothing but gas and their walls were always dry and glistening. The inner wall was thin, light and more transparent than the other. One of these loops was twisted around the other two, partially obstructing them, thus causing the symptoms of obstruction from which the man suffered.

Microscopic Examination.—The tumors stood in intimate relation with the walls of the intestine and consisted of a multitude of cavities of varying size, of which the larger were situated in the center and toward the free surface, while the smaller were adjacent to the walls of the intestine or within their thickness. Each cyst had a definite wall made of connective tissue, inside of which there was a lining membrane composed of a compact layer of very flat giant cells of various shapes up to 1 mm. long, packed closely together and containing numerous, sometimes hundreds, of nuclei of round and slightly oval shape. The protoplasm was slightly granular and more or less pigmented. Numerous dilated blood vessels were found all around the cysts. The smaller the cysts the less developed was the connective tissue wall and the smaller the giant cell of the lining membrane. Kouskow thought that these cysts had their beginning in connective tissue cells which in the course of development lost their processes, became more round or oval and then on nuclear cleavage grew into polynuclear giant cells. In the course of this growth, they became more and more pigmented, while the interstitial tissue and the connective tissue cells which had not undergone the progressive changes became atrophied and disappeared. When the cells reached the size of giant cells, cavities began to form around them, the contents of these cavities being, even at this early stage, gas. Kouskow believed that the gas was extracted from the circulating blood and owed its origin to a specific function of the giant cells lining the cysts. As regards the time at which the cysts originated, he took the rather original view that they were of embryonal origin, like the majority of newly formed cysts.

WINANDS' CASE.

History.—In May, 1890, a woman, aged 49, died in the Marburger Medical Clinic, who had suffered for a number of years from severe pain in the abdomen, constipation, which at times amounted to an obstruction, and meteorism. The latter at times assumed such threatening proportions that a fine trocar was plunged into the intestine in order to permit some of the gas to escape.

Macroscopic Examination.—At autopsy, performed forty-four hours after death, an old ulcer and dilatation of stomach were found, but in addition the greater part of the ileum and the ascending colon were found covered with innumerable translucent cysts, some of which were situated in a pseudo-membrane covering the bowel, the remains of an old peritonitis, and formed clusters like a bunch of grapes, while others were in the intestinal wall itself. The cysts were mostly on the convex surface of the bowel, varied in size from a pea to a cherry, and contained a gas which had no odor, did not burn and contained only a small amount of CO_2 (enough gas for an exact analysis could not be collected.

Microscopic Examination.—The serosa generally was only a bit thickened. The mucous membrane was intact. The muscularis mucosa was, in the region of the cysts, very much hypertrophied. The submucosa was replaced mostly by a homogeneous-looking tissue, poor in nuclei, while in the region of the cysts, it was almost entirely absent. These (the cysts) lay both in the circular and longitudinal muscle which had undergone atrophy in their neighborhood, due to their gradual growth and the consequent pressure. Some cysts had become united through the partial atrophy of their walls. They had an endothelial lining for the most part, and a wall outside of this made of connective tissue. In their neighborhood numerous little hemorrhagic areas were seen. The great number of lymph vessels also was striking. They were dilated and filled with a granular coagulation mass, probably the earliest stage of cyst formation. Nowhere was a junction between the blood and lymph vessels and the cysts to be found. In some of the small, dilated lymph spaces large irregular giant cells having twenty to thirty nuclei (probably springing from the endothelium) were to be seen. Similar cells were also occasionally found in the walls of the larger cysts.

Numerous short bacilli of various sorts were present on the inner surface of the cysts, while only a few were in the neighboring tissues. Their form and arrangement, however, were not characteristic enough to separate them from the usual putrefactive organisms.

HAHN'S CASE.

History.—Man, aged 35, had suffered for two years from pain in the abdomen, accompanied by alternate diarrhea and constipation. On examination the stomach was found to be greatly dilated. The constipation gradually got worse, amounting finally to an obstruction which demanded operation.

Examination.—On opening the abdomen, innumerable cysts were found all over the intestine, large and small, some of which were pedunculated, some flat on the serosa, from which alone they all sprang. They looked like ecchinococcus cysts, but contained a gas which did not burn. There was no tumor and the pylorus was patent, but the stomach and ascending colon were greatly dilated. Some of the cysts were removed entirely, others simply punctured, as many as possible being handled, and the abdomen was closed. The patient was able to have a good stool ten days later after an enema, and was discharged much improved, though not well. Six months later his condition was still fair, but he was troubled greatly by constipation. The cysts were on the convex side of the bowel and varied in size from a pea to a cherry. The intestinal musculature was atrophied. Cocci grew on culture, but it was impossible to determine their exact nature.

KORTE'S[23] CASE (DISCUSSION OF HAHN'S PAPER.)

History.—A woman, aged 62, was operated on in 1878 for an incarcerated crural hernia, and died seven days later with signs of peritonitis. At autopsy, performed very soon after death, the pylorus was found narrowed by the scar of an old ulcer, and the stomach was greatly dilated. The small intestine was irregularly contracted and narrowed in numerous places and contained in its walls cystic tumors varying in size from a pea to a cherry, which, when opened under water, set free bubbles of air. They were sharply outlined, the air could not be pressed hither and thither like an emphysema of the connective tissue. There was no inflammation in the neighborhood. The microscope showed the cysts to be in the submucosa, no endothelial lining could be made out.

WIKERHAUSER'S[24] CASE.

Macroscopic Examination.—In the course of an operation on a man, aged 35, for gastroenterostomy to relieve a dilated stomach, the result of stenosis of the pylorus following an old ulcer, the intestines were found covered with round grape-like bodies, varying in size from a millet seed to a small cherry.. They occurred singly on a small pedicle, or in larger or smaller aggregations, being usually on the side opposite to the mesentery, though in some places the intestine was completely surrounded. When touched with the fingers, they crepitated and

23. Deutsch. med. Wchnschr., 1899, xxii, 255.

24. Pneumatosis cystoides intestinorum hominis, Hahn. Liec. viestnik u. Zagrebn., 1900, xxii.

when broken or punctured contained only air. After removing some of them for examination, the gastroenterostomy was finished and the abdomen was closed, but the patient died two weeks later of peritonitis. At the autopsy the viscera were so matted together that no trace of the cysts could be found.

Microscopic Examination.—Those removed showed that they were lined with an endothelium which in places was hypertrophic and two or three rows thick, while in others the cells had two or more nuclei.

MIWA'S[25] CASE.

History.—Male, aged 42, who had suffered for years from "stomach trouble" and tuberculosis of the lungs and spine. On admission, besides the tuberculosis, the stomach was dilated, reaching to the umbilicus. Soon afterward the abdomen became distended, there was pain and vomiting, the stomach was three fingers below the umbilicus. Diagnosis uncertain, but pylorus was thought to be stenosed. The patient's condition became steadily worse, death ensuing shortly after.

Examination—At the autopsy, nine hours later, numerous air cysts, varying in size from a hemp seed to a pigeon's egg, were found situated on a part of the ileum, having a length of 30 cm. (12 in.). They were placed very near and on top of each other and were in both the serosa and submucosa. They exploded on pressure with the finger. The lumen of the bowel was narrowed at their situation. The air in the cysts neither smelled nor burned; they had no pedicles. No other part of the intestine was involved. Microscopically no characteristic bacteria were found, but gas was produced in culture on sugar-agar.

TIBOR VEREBÉLY'S CASE.

Macroscopic Examination.—At the autopsy performed on a man, aged 30, who had died of pulmonary tuberculosis, there were found, in addition to a dilated stomach due to an ulcer on the lower ileum and cecum, numbers of rather flat cysts occurring singly or in groups, which contained an odorless and non-inflammable gas. A few, however, on being opened, discharged a solid yellow matter.

Microscopic Examination.—The cysts were found in all the layers of the intestine, mostly, however, in the submucosa. They were lined with endothelium and contained many giant cells, also cheesy masses in their walls. Numerous tubercu-

25. Ueber einen Fall von Pneumatosis cystoides intestinorum hominis nach Prof. Dr. Hahn, Centralbl. f. Chir., 1901, xvi, 427.

lous abscesses were noted in the intestine. Bacterial examination being negative, the author considered that the gas in the cysts came from the intestines by way of the tuberculous abscesses and that the enlargement of the stomach was also partly responsible.

JABOULAY'S CASE.

History.—Man, aged 50, who had suffered eight years from a greatly dilated stomach due to stricture of the pylorus from an ulcer. At operation, in addition to finding the pylorus stenosed by an old cicatrix, numbers of gas cysts, varying in size from a pin head to a small nut, were found covering the small intestine. There was also a sort of nest of them on the diaphragm at about its center. Nothing at all was done to the cysts, it being thought best to treat them like a tuberculous peritonitis, i. e., simply let them alone. The pylorus was dilated and the abdomen closed. The patient recovered from this condition and was improved. Jaboulay inclines to the microbic origin of the cysts, but gives no proof, not having made any bacteriologic or histologic examinations.

WILLIAM THORBURN'S[26] CASE.

Macroscopic Examination.—A woman, aged 42, was operated on Sept. 19, 1902, for enormous dilatation of the stomach. A cicatrix was found near the pylorus, which, however, was patent. A thick band of adhesions, four inches long, was found constricting the stomach. During the removal of this there was found to the right of the great omentum a collection of rounded cystic masses, extending into the right hypochondrium. The numerous cysts varied in size from that of a pea to that of a walnut and were closely packed together in the form of a cone, of which the apex lay some two inches from the middle line, while the base rested near the hepatic flexure of the colon and deeply in the right flank. When dissected out, it resembled a cluster of hydatid cysts. Each little cyst had a thin transparent but well-defined wall, they were separated only by a delicate fibrous tissue of greater tenuity than the omentum itself. Some contained a thin colorless fluid, rather more glutinous than serum, but the majority were filled with an odorless gas. The excision of the remarkable cone was followed by the discovery of an almost precisely similar collection on the left side of the omentum with its base passing beneath the spleen. As a rough exami-

26. Gastric Ulcers; Perigastric Adhesions; Enormous Dilatation of the Stomach: Gas-containing Cysts in the Omentum: Med. Chronicle, 1902-3, iv, 256.

nation of the first mass had shown no evidence of cancer or of hydatid cysts, the second mass was not removed. The patient died about four weeks later with symptoms of a perforated ulcer of the stomach. No autopsy was obtaiend.

Microscopic Examination (made by W. Mair).—This showed that some of the cysts had an endothelial lining while others did not. Multinucleated giant cells were found both in the wall of the cysts and lying free in the lumen, also in some connective tissue nodules found in the supporting framework of the tumor mass. Fibrocytes were likewise found in these latter places. Dilated blood capillaries and vessels surrounded the cysts.

NIGRISOLI'S[27] CASE.

Macroscopic Examination.—A man, aged 25, had suffered for some years from symptoms of ulcer of the stomach and intestinal obstruction and came to operation for their relief. On opening the abdomen, in addition to pyloric stenosis, a part of the small intestine about 60 to 70 cm. (24 to 30 in.) long was found to be covered with groups of fine shining cysts, resembling somewhat ecchinoccus cysts. Some of them were pedunculated and isolated, while others occurred in masses. Their size ranged from that of a pea to a small nut, sometimes they were round, sometimes oblong. On breaking them, a gas escaped, which had no odor and did not burn. They were most numerous along the insertion of the mesentery. Numerous dilated blood vessels ran all over them. After removing a few for examination, a gastroenterostomy was done by means of a Murphy button. The patient did well until about three weeks later, when the button ulcerated through the bowel, causing death by peritonitis. At the autopsy no trace of the cysts on the intestine or on the mesentery could be found.

Microscopic Examination.—The cysts showed that they had an endothelial lining, and a wall made of connective tissue.

KADYAN'S[20] CASE.

Macroscopic Examination.—A woman, aged 31, was operated on for tuberculous peritonitis. On opening the abdomen the intestines were found covered by a mass of tubercles of varying sizes, among which were numerous vesicles, the dimensions of which ranged from a pin head to the size of a cherry. Some were suspended by pedicles. They were perfectly transparent, and all were filled with air, collapsing when punctured. On the large intestine the process was less marked.

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27. Sulde cisti gassose dell' intestino umano. N. Raccoglitore med., Imola, 1902.

The abdomen was closed without anything being done. The patient had suffered a great deal from ascites and constipation, so that the diagnosis before operation lay between tuberculous peritonitis and chronic partial stenosis of the intestine. As no stenosis, however, was found at operation, the condition was interpreted as being tuberculous peritonitis complicated by the formation of gas cysts. The patient was better for a time, but as the ascites and constipation recurred with increasing severity, the abdomen was again opened about three weeks after the first operation. The picture as regards the cysts was approximately the same as at the first operation, but the tubercles had entirely disappeared. After puncturing and mashing some of the cysts, therefore, and after removing those suspended on pedicles, the abdomen was again closed. Two months later, that is, on Feb. 19, 1894, as the patient's condition again got worse, a third laparotomy was done. The small intestines were covered with air cysts of all possible dimensions, from a pin head to the size of a cherry or larger. Many of them were pedunculated. On pressure they burst, but, as before, contained only air. The tubercles were still absent, being replaced by whitish spots. The patient recovered from the operation, and at her discharge, although there was still distention and fluid in the abdomen, the pain and constipation had been relieved. The patient was lost sight of. The cysts contained no fluid, but only an odorless gas.

Microscopic Examination.—This showed the cysts to have a fibrous wall, which was lined by one or several layers of large round cells of the endothelial type.

T. STORI'S[11] CASES.

CASE 1.—*History.*—While doing a gastroenterostomy on a woman, aged 38, for stenosis of the pylorus and dilatation of the stomach, a round mass, looking like insufflated lung tissue, and about the size of a nut, was found lying above the gastrohepatic ligament. It was made up of many round cysts ranging in size from a pin head to a bean, the walls of which were thin and transparent. They contained a gas which had no odor and did not burn. No other similar growths were to be found. After removing a portion of the mass for examination, the gastroenterostomy was finished and the abdomen closed. The patient made a good recovery.

CASE 2.—*Macroscopic Examination.*—A man, aged 30, had suffered for some years from pain in the abdomen, especially after meals, vomiting and had lost weight. On examination the stomach was found greatly dilated, and in the right in-

ferior portion of the abdomen a crepitus, similar to that present in a localized peritonitis, was obtained on pressure. A diagnosis of stenosis of the pylorus was made. After performing a gastroenterostomy, it was found that about a meter (39 in.) of the ileum near the cecum was surrounded by a gray mass, lobulated and soft, like insufflated lung tissue. It arose from the mesentery and some of the lobules were pedunculated, while others were not. The lobules had very thin walls, were transparent, ranged in size from a pin head to a small nut and contained an odorless and non-inflammable gas. After removing a small portion for examination, the abdomen was closed, the patient making a good recovery.

Microscopic Examination.—The walls of the cysts were made up of connective tissue, inside of which was a layer of endothelial-like cells. Some of the cavities communicated. In view of their characters, relations and form of endothelium, Stori thought that they were lymphatic cavities dilated to different degrees. The surrounding blood vessels were dilated and engorged with blood, and there was some small round-celled infiltration around them. Stori isolated from a fragment of the cyst of the second case a coccus, resembling a diplococcus, which produced gas on lactose agar cultures. Animal experiments, however, were negative.

M. MORI'S[19] CASE.

History.—A man, aged 37, complained for eight years of a feeling of fulness in the stomach after eating, sour belching and very obstinate constipation. He gradually got worse, suffered greatly from colicky pains in the abdomen, vomited frequently, was badly constipated and had no appetite. In addition, there was some general edema. The abdomen was greatly distended, especially below the umbilicus, and the stomach was considerably dilated, reaching as low as the symphysis. At operation, Nov. 10, 1906, the whole of the small intestine, except the upper part of the jejunum and the lower ileum, was covered with innumerable air cysts varying in size from that of a hemp seed to a walnut, occurring sometimes in the form of a bunch of grapes having a pedicle and sometimes singly and flat on the serosa.

Believing that this condition was partly responsible for the dilatation of the stomach and the patient's pain, Mori did an anastomosis between the two healthy parts of the bowel in the hopes that the intestinal contents would thus have an easier passage and, in addition, that possibly the pathologic condition would disappear. He also did a gastroenterostomy, as

the pylorus was drawn high up by adhesions which could not be broken down. The patient was discharged, much improved, nineteen days later.

Microscopic Examination.—The cysts were situated almost entirely opposite to the mesenteric insertion—not on the mesentery at all. The muscle of the intestine was atrophied. The walls of the cysts were very thin and broke easily when pressed by the finger, setting free a gas which did not burn. Many layers of connective tissue having few nuclei made up the walls. There was no endothelial lining. In the lumen of most of the cysts there was, as a rule, nothing, but in a few there was a homogeneous coagulated bullet-shaped mass. Numerous cocci and bacilli were found here and there, both in the lumen and the tissue round about.

Nine months after the above operation it became necessary for Mori to perform a second laparotomy on the patient because of pain in the abdomen and symptoms of obstruction due to adhesions. To his surprise, there was not a sign of a cyst to be seen on any part of the gut. On this account he was inclined to give up his former view as to the cause of the cysts, namely, bacterial, coming rather to the conclusion that the entire condition is due to circulatory disturbances. If these be relieved, as in his case, by short circuiting the diseased or affected area, he believes that the prognosis is good for a complete recovery.

W. MAIR'S[8] CASE.

History.—During a gastroenterostomy for pyloric stenosis on a young man, 23 cm. (9 in.) of the small intestine were found involved in a tumor mass made up of cysts and was resected. The tumor had given no symptoms. The patient recovered.

Macroscopic Examination.—The specimen consisted of a lobulated mass of gas-containing cysts, the smallest being barely visible, the largest about the size of a walnut. With the exception of a very few small ones close to the bowel, the mesentery was not involved, most of them being situated opposite to the mesenteric attachment. The cysts did not communicate, but were connected by strands of vascular tissue. Some contained a small amount of fluid, but most of them, when punctured collapsed with the escape of an odorless gas. Cultures on agar were sterile.

Microscopic Examination.—Some of the cysts had an endothelial lining. Multinucleated giant cells were found both in the wall of the cysts and lying free in the lumen. In addition,

there were some connective tissue nodules in the supporting framework of the tumor mass. Fibrocytes were likewise found in places. Dilated blood capillaries and vessels surrounded the cysts. Mair considered the condition a true neoplasm, the youngest stage of which was the fibrous nodule, the gas being secreted from the blood through the thin-walled dilated vessels surrounding the cysts—a phenomenon long known to occur in fish.

GRONDAHL'S[28] CASE.

Macroscopic Examination.—At the autopsy of a man, aged 31, who had suffered for some years from symptoms of ulcer of the stomach, in addition to a constricting ulcer in the duodenum and an enormously dilated stomach, one meter (39 in.) of the ileum was found to be covered with innumerable cysts. These varied in size up to that of a bean, were situated close together and occurred sometimes singly, lying flat on the serosa, sometimes in groups and occasionally at the end of a long and thin pedicle. Numerous small hemorrhages were to be seen. On pressure the cysts burst and contained a gas that neither burned nor had an odor, and on analysis was very similar to atmospheric air. Only the free border of the bowel was involved, no cysts being on the mesentery itself.

Microscopic Examination.—The cysts occurred in the mucosa, submucosa and serosa and had, as a rule, an endothelial lining, and outside of this a wall of connective tissue poor in nuclei. By serial sections the author claimed to be able to distinguish the union of the lymph vessels with the cysts. In some collapsed cysts occurring in the submucosa, numbers of many nucleated giant cells were to be seen. These were considered to be due to a proliferation of the endothelium. Many of the cysts showed little hemorrhages in their lumen, while others were filled with young granulation tissue. No cultures were made. A Gram-positive organism was, however, found in the proliferating lymph vessels, but it was neither characteristic nor frequent enough to be of any value.

Grondahl leans to the view that the condition is caused by an infection. He, however, brings no proof to bear, contenting himself with saying that it is difficult to think of it as caused by anything other than an infection. The cases of Durvenoy, Cloquet, Dupraz and Orlandi referred to by some authors as instances of this

28. Deutsch. med. Wchnschr., 1908, p. 913.

condition are, I believe, unquestionably due to postmortem changes, the result of gas bacillus infection, except, perhaps, the case of Dupraz, which he himself refers to as a case of proliferative lymphangitis. The case of Machiafana mentioned by Winands has to do with serous cysts only and does not belong here.

DISCUSSION.

DR. WILLIAM H. WATHEN, Louisville, Ky.: All that we seem to know about this tumor is that it consists of increased connective-tissue growth in which are numerous loculi filled with air in the lower part of the ileum. It is not positively known whether this excessive growth is entirely of connective tissue. There can apparently be but three sources of gas in this tumor—bacteria tissue products or pressure forcing the gas from the bowel into the cyst. There is no definite condition that tells us which of these theories must be accepted. It seems that nearly every one of the few observed cases has been associated with a constriction of the intestine near the pylorus, obstructing the flow into the lower bowel, but in the lower animals that have been examined there was no such constriction. Hence the idea of assigning the constriction as a cause can not be tenable, for the reason that the anatomic structures of the gastrointestinal tract in the lower animal are practically identical with the anatomic structures of the human being. We have never been able to diagnosticate one of these tumors until an exploration was made for some other trouble or at a postmortem examination. Fortunately, it appears that these tumors are not a serious danger to human life. It is easy to understand that, in any condition in which there is an obstruction of the circulation in the bowel and an increased growth of connective tissue in the muscularis of the bowel or in the connective tissue of the peritoneum by pressure alone gas could be forced out into these loculi. On a similar hypothesis, where the same condition exists, gas might form by the passage of bacteria into these loculi, but the bacteriologic examinations have up to the present been so unsatisfactory and conflicting that we know but little about that. We should probably be more likely to find some variety of colon bacillus, because the condition is located in the lower ileum, though it seems that a few bacteriologists have asserted that they have found some cocci in these tumors.

DR. J. M. T. FINNEY, Baltimore: This tumor is very rare, the instance reported being the first that has been observed in this country. The chief interest centers in its etiology, and this will, for the present at any rate, have to remain unknown.

Whether it is a tumor of distinct character or whether of bacterial or obstructive origin is as yet undetermined. Histologically the tumor is of great interest. The disease appears to be confined to no one locality, but is widely disseminated, cases having been reported from Norway, Russia, Japan, Italy, France, Germany and England, but only one or two cases from each country. If the tumor is of bacterial origin, and the bacteria giving rise to it are of the colon group which are so common, it would be interesting to know why it does not occur more frequently.

PRELIMINARY REPORT OF THE ANESTHESIA COMMISSION OF THE AMERICAN MEDICAL ASSOCIATION.

Last year at the meeting of this section in Atlantic City, the then Chairman, Dr. Bevan, made some interesting remarks on the value of nitrous oxid as a general anesthetic, and ventured to predict its more common adoption for major surgical procedures. So much interest was aroused by his statements, that this section resolved to appoint a commission to investigate broadly the subject of the numerous anesthetics, old and new, in order that, after proper deliberation, we might set forth an authoritative estimate of their proper value for the profession. In accordance with that resolution a commission was appointed, which has been engaged for some months on the prescribed problem.

Our task is far from simple. The ground to be covered is wide. The opinions of leading surgeons are often opposed and the anesthetics struggling for recognition are held in varying esteem by responsible persons of divergent views. In consideration of these facts, therefore, we have determined to advance slowly with our task, to weigh carefully the claims of the various anesthetics, to set forth soundly and without prejudice their sundry merits and demerits, and to present in the end a series of recommendations, which we trust may commend themselves to you.

Accordingly, we propose—through ourselves or our successors in this office—to investigate yearly one or two drugs only. As a preliminary to this investigation, we have this year collected papers on a number of anesthetics, their more popular methods of administra-

tion, and the claims made for them by their most enthusiastic advocates. These papers, tentative, and lacking our unanimous endorsement, we shall publish in our printed report this year.

CHLOROFORM-ETHER.

The work so far has established certain interesting facts. For example, we find that the old chloroform-ether controversy is still active, in spite of the extensive investigations and elaborate findings of numerous physiologists and committees similar to our own. We are told that the practice of surgeons, in their use of anesthetics, has been but little altered by the above-named scientific investigations—that the users of ether still use that drug invariably—and that the users of chloroform still cling to chloroform. We believe that the actual facts regarding the safety and advantages of these two anesthetics are but little questioned, but we are convinced that the divergence of opinion is due today largely to certain conceptions and misconceptions regarding the methods of their administration.

Most men agree that all anesthetics in the hands of inexpert anesthetists are dangerous, while all agree that all anesthetics. in the hands of experts, and applied to suitable cases, are commonly free from danger. As an academic proposition such a statement is well enough—but unfortunately, when we consider the wide demands of a medical and surgical practice which embraces the whole civilized world, and is conducted mainly by general practitioners of little special training as anesthetists, we are forced to regard primarily the dangers and the disadvantages of general anesthetics when used by the inexpert. The problem is quite different regarding the use of anesthetics by the expert. In our researches and recommendations we shall endeavor to bear in mind these two phases of the ether-chloroform problem—the use of these drugs by the expert and the inexpert.

SPINAL ANESTHESIA.

Within recent years other drugs have been forced to the front, as well as novel methods of employing old drugs. Spinal anesthesia is one of the most important of the new methods. It is gaining constantly a broader and more favorable recognition, as its just claims are being acknowledged, and its limitations are being appreciated. One of our collaborators states: "It is my belief that it (spinal anesthesia) has come to stay and will always, in certain cases, prove safer and more satisfactory than any general anesthetic which we now have. I have used it since 1900 in cases where I have seen a clear contraindication to both chloroform and ether, and I have as yet no occasion whatsoever to regret its use. In all I have used it about 150 times, and have statistics of more than 1000 cases without a death. . . . I believe it is particularly indicated in the surgery of the prostate and the rectum, where it is sometimes desirable to have the cooperation of the patient during certain steps of the operation. In all of my cases the operations have been below the diaphragm. Morton and others report analgesia of the upper extremities, even the tongue, where the agent is thrown into the spinal canal with considerable force. . . . While my experience with cocain sterilized by the fractional method was entirely satisfactory, I have given it up for stovain, on account of theoretical considerations. The latter substance stands a temperature beyond the boiling point, and therefore is free from objections which obtain with cocain. We have had less postoperative nausea and headache with stovain. . . . As to the indications for spinal anesthesia: I consider it safer than general anesthesia, (1) in drunkards; (2) in cases of marked nephritis with accompanying heart lesions I am satisfied that it is safer than either of the general anesthetics usually employed; (3) it certainly has seemed to me better in operations of necessity on diabetic subjects; (4) in marked bronchitis,

emphysema probably associated with cardiac lesions, and arteriosclerosis; (5) in herniæ, and operations on the prostate and rectum, where it may be desirable to have the patient cough and strain during the operation. The average duration of analgesia has been about one hour and thirty-five minutes. . . . Every patient on whom it (spinal anesthesia) has been used, with the exception of one, a diabetic nearly 80 years of age, whose leg I amputated, recovered. He died many days afterward in the usual way of diabetic coma." We report these views as they embody the convictions of a surgeon of wide experience.

NITROUS OXID.

Nitrous oxid, one of the oldest of general anesthetics, is coming into use for major operations. We are familiar with its employment by dentists and by surgeons for minor operations, as well as with its use to induce anesthesia as a preliminary to ether—but its employment combined with air throughout major operations is still something of a novelty, while its greatest advantage is that it is the safest general anesthetic known.

H. A. Kelly and A. D. Bevan have employed it for operations of the first magnitude, and have shown that the patient can be carried along under its influence comfortably and safely for more than an hour. With Bevan it is the anesthetic for the reduction of fractures and dislocations; for operations on felons; for breaking up adhesions in joints; for draining empyemata and lung abscesses; for exploratory abdominal sections; for operations on the biliary passages; for nephrotomy, nephrectomy and nepholithotomy; for suprapubic cystotomy for stone, and for suprapubic prostatectomy; for draining an appendiceal abscess; for colostomy, gastrostomy and enterostomy; for the repair of typhoid perforations, and of gastric and duodenal ulcers; for the radical cure of hernia and the relief of strangulated hernia; for hydrocele and varicocele; in castrations; in

amputations, except at the largest joints; and for the removal of benign tumors.

This is an important and striking list, and it covers many of those conditions for which one surgeon might choose spinal anesthesia, another local anesthesia, and another one the more familiar general anesthetics. How shall we reconcile divergent views?

LOCAL ANESTHESIA.

Within recent years certain surgeons speaking with authority have urged us to employ local anesthesia in the case of many major operations, and last year J. P. Mitchell, of Washington, read before this section an important account of his experience with local anesthesia. Your commission have had the advantage of Dr. Mitchell's cooperation in preparing this report. With widening practice and endeavor, he finds the scope of local anesthesia to be surprisingly broad. The method is applicable not only to minor operations, but to all amputations of limbs, to operations on bones, to the exploration of the abdomen, for typhoid perforations, for appendectomy, for all forms of hernia, for all operations on the male genital organs, and for most benign tumors. We shall publish in our complete report Mitchell's brief final statement on this subject of local anesthesia.

RECTAL ANESTHESIA.

Rectal anesthesia by ether, after being tried and abandoned nearly twenty years ago, is now being practiced with success and advantage. The improved technic and good results of Cunningham of Boston and Brewer of New York, show this form of anesthesia to be safer than at first was supposed. In the case of carefully prepared patients and a gradual administration of the anesthetic through a suitable apparatus, good results can be obtained. The method is, of course, an ideal form of anesthesia for all head and neck operations. The method is valuelss and dangerouos in unskilled hands.

Its use implies careful preparation of the rectum, a special apparatus, and a patient, intelligent administration.

In from three to five minutes from the time the etherization is started the odor of ether can be perceived in the patient's breath; in two or three minutes more he becomes drowsy, his eyes cloose, his breathing becomes tranquil, regular, and slightly stertorous, and he passes into complete anesthesia, usually without excitement or struggling. The time necessary for the production of complete anesthesia by this means varies from six to fifteen minutes, and the condition once established is maintined easily for an indefinite period.

There are numerous special methods of anesthesia suitable for special conditions, for special patients, and for special operations. Freeman Allen of Boston has supplied us with an interesting brief paper on these matters. He deals with brain operations, eye and ear operations, nose and throat operations, resections of the jaws and tongue, the dissection of goiters, of cervical lymph nodes; and with operations on the larynx and esophagus. He discusses the preparation of the patient for inhalation anesthesia. He describes scopalamin-morphin anesthesia, rectal anesthesia, and such special methods as Crile's and Fillebrown's. Allen's paper also will be published in full.

From the brief statements which we have set forth, you will see something of the breadth and of the intricacy of the present-day problem of anesthesia. As we have already stated, it is a striking fact that all the newer methods demand expertness, experience and special apparatus. They appeal especially to surgeons who are equipped with the paraphernalia of expensive and highly specialized clinics. They are little suited to physicians in general practice. For the latter great class of practitioners, the old general anesthetics, chloroform and ether, will probably hold their own until increasing experience has enabled us to simplify and to make safe the newer and more novel methods.

RECOMMENDATIONS.

We submit three recommendations regarding general anesthetics:

1. That for the general practitioner, and for all anesthetists not specially skilled, ether must be the anesthetic of choice—ether administered by the open or the drop method.

2. That the use of chloroform, particularly for the operations of minor surgery, be discouraged, unless it be given by an expert.

3. That the training of skilled anesthetists be encouraged; and that undergraduate students be more generally instructed in the use of anesthetics.

We believe that the further use of nitrous oxid, combined with air or oxygen, in major surgical operations, is promising.

J. G. Mumford (Chairman), Boston.
J. F. Binnie, Kansas City.
C. A. Powers, Denver.
W. D. Haggard, Nashville.
W. L. Rodman, Philadelphia.
Anesthesia Commission.

METHODS OF ADMINISTERING ETHER.*

Prepared under the direction of F. J. Binnie, M.D.

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Statistics regarding the death rate of anesthetic agents, although open to grave fallacies, show that ether is by far the safest general anesthetic we have,

* The following papers by Drs. Cunningham and Anderson, Haggard, Mitchell and Allen were prepared with the cooperation and under the direction of the Anesthesia Commission. They are papers which embody the results of recent research, and are published by the commission for the matters of exceptional interest which they contain. The paper by Dr. Hamburger and Dr. Ewing was prepared in connection with the interesting clinical work of Dr. A. D. Bevan, and is courteously contributed by the authors.

with the exception of nitrous oxid. In reviewing the statistics, it is a noticeable fact that the death rate, both immediate and late, under the more experienced anesthetics, is so much lower than in the hands of those not skilled in this line of work, that it would seem that deaths are due more to faulty administration, or the selection of the anesthetic unsuited to the case, rather than to the anesthetic itself.

The most reliable statistics from all parts of the world give an average of one death to about every sixteen thousand administrations of ether. Dr. Julliard, of Geneva, reports from various reliable sources 314,738 administrations of ether with twenty-one deaths, or a death rate of one in 14,987. Dr. Ormsby, of Dublin, reports 92,815 ether administrations with but four deaths, or one in 23,204. Professor Tripier reports 6,500 cases without a death, and Alice McGraw 15,000 personal cases without a death. Dr. Rabatz reports 150,000 cases of ether administrations without a death.

PRIMARY CAUSES OF DEATH.

Turnbull reviews the literature (1888-1895) of eleven cases of death from ether. Death occurred in less than one minute after the administration was begun in three cases, and within the first few minutes in four of the other cases. One patient died "during the operation," and one at the end of one and one-half hours. The time of death of the other two patients is not recorded. It appears that most deaths from ether occur during the stage of excitement or before complete narcosis is established, and is probably due to functional disturbances of reflex origin. In deaths from ether it rarely happens that cardiac failure precedes respiratory failure. The deaths that occur during the surgical stage of anesthesia appear to be due to anesthetic shock.

METHODS OF ADMINISTRATION OF ETHER.

CLOSED METHOD.

This is obtained by fitting a closed cone closely to the face, or by the use of inhalers provided with pliable bags for the purpose of rebreathing. The more flexible the material of which the cone is made the more it will permit of rebreathing.

Advantages.—1. The rebreathing gives a much quicker narcosis.

2. Only a small amount of refrigeration because of the retention of the warm exhaled air.

3. A good diffusion of ether vapor and air, therefore less irritation and less chance of a hypersecretion of mucus.

4. A small amount of ether is necessary because of the rebreathing.

Disadvantages.—1. The rebreathing causes a decreased oxygenation, which predisposes to toxic effects of the anesthetic agent. It also gives a respiration greatly increased in carbon dioxid, and produces toxic effects from the organic materials of expired air.

2. It is impossible to regulate the dosage (even approximately) because of the necessity of pouring the ether into the cone or inhaler intermittently. This uneven administration permits of the possibility of exceeding the safety margin and also predisposes to anesthetic shock.

3. The method is very disagreeable to the patient because of a feeling of impending suffocation in the first stage, which often causes extreme fright and struggling.

OPEN METHOD (DROP METHOD).

The open method consists in the use of a small metal frame-work covered with gauze on which the ether is continuously administered by drops.

Advantages.—1. There is little or no rebreathing which permits of the normal oxygenation, no increase

of carbon dioxid or poisoning from exhaled organic substances.

2. It permits of the administration of a safe and fairly uniform ether vapor.

3. The induction period with low vapor strength does not produce a feeling of suffocation, and induces anesthesia with a minimum of distress to the patient.

4. The full oxygenation of this method is conducive to complete muscular relaxation and prevents exaggerated abdominal breathing.

5. Its simplicity and adaptability for the inexperienced anesthetist.

6. Its safety has been demonstrated by extensive usage.

Disadvantages. — 1. Produces great refrigeration. Whatever heat is taken from the inspired air by the vaporization of the ether is in turn taken from the lungs, as the exhalation is always at practically body temperature, regardless of the temperature of the inhalation. Experiments have demonstrated that a room at 80 F., 2.1 per cent. ether vapor reduces the inhalations to 30 F., and 5.4 per cent. ether vapor to 9 F., thus causing a loss of about 21,000 calories of body heat for every ounce of ether used. If refrigeration is a factor in the production of post-anesthetic pulmonary complications, the open or drop method, which is the most efficient of all methods in extracting heat from the patient, would seem to invite the occurrence of post-anesthetic pulmonary involvement. If refrigeration adds to shock, the open or drop method would, regarding the production of shock, head the list of all the methods of administering ether.

2. Incomplete diffusion of ether vapor and air because of the close proximity of the application of the liquid ether to the face.

3. Unduly large amounts of ether required because of the waste of ether from its vaporization by the exhalation.

4. Room may become saturated with ether vapor during long anesthesias.

5. Longer time necessary to induce anesthesia.

SEMI-OPEN METHOD.

This is obtained by a modification of either of the preceding methods so that the air supply may be controlled, thus causing a limited amount of rebreathing. The appliances used are usually:

1. The mask as used in the open or drop method, with additional layers of gauze or gauze surrounded by towels.

2. A cone containing gauze with both ends open.

3. Any one of the several inhalers (Ormsby's, Braine's and others) with mechanical devices for limiting the air supply.

The semi-open method partakes of the advantages or disadvantages of the two preceding methods to the degree that it approaches one or the other.

MECHANICAL ADMINISTRATION.

Another method of administering ether is by means of an apparatus (Cunningham's) by which the strength of the ether vapor is controlled mechanically by definite percentage, thus giving an even measured dosage. Excessive refrigeration of the inhalation is prevented by means of radiation from a chamber of warm water. But little ether is used because the exhalation does not come in contact with the ether. The inhaler is small so that there is little or no rebreathing. The apparatus has the advantage of simplicity, and the passage of the inhalation through the apparatus gives a thorough mixtue of air and ether vapor.

RECTAL ETHERIZATION.

Various apparatus have been used for rectal etherization, some of which have met with fair success.

Advantages.—1. Postoperative nausea and vomiting has been practically absent with this method, and recovery is rapid.

2. Is well suited for operations on the nose and mouth because the anesthetic materials are out of the way.

3. It is well suited in cases of extreme pulmonary or bronchial involvement.

4. A small amount of ether is used.

5. It is not disagreeable to the patient. There is little or no stage of excitement.

Disadvantages.—1. The induction is unusually long.

2. It fails to produce anesthesia in some cases.

3. It is difficult to regulate the dosage.

4. Colicky pains, diarrhea and painful distention of the intestines sometimes follow this method of etherization. This method has had some fatalities, although it has been used without a fatality in a series of 15,000 cases.

NITROUS OXID—ETHER SEQUENCE METHOD.

This is obtained by several different apparatus (Clover's, Hewitt's, Bennett's Pedersen's and others), by which nitrous oxid is given until narcosis is obtained, then followed by ether vapor and nitrous oxid, then continued with ether vapor and air. It is necessary for the gas-ether apparatus to employ the aid of anoxemia by the use of a rebreathing bag to maintain a narcosis between the discontinuance of the gas and until the state of complete etherization is obtained. It is necessary to discontinue the administration of the gas early because of the asphyxiation which would follow otherwise.

Advantages.—1. Since narcosis is produced first by gas, the odor of the ether and distress of the induction period is abrogated. Thirty seconds is usually sufficient to produce nitrous oxid narcosis.

2. Surgical ether anesthesia is obtained in from two and one-half to four minutes.

3. Statistics show that the gas-ether sequence is much safer than the administration of ether alone. This is probably due to the elimination of the stage of excitement which is the most dangerous stage of anesthesia.

4. A small amount of ether is necessary to continue anesthesia because of the rebreathing of this method.

Disadvantages.—1. It requires considerable skill for its administration.

2. The cyanosis from the gas and the clonic spasms which sometimes follow is, perhaps, free from danger, but is frightening to those unaccustomed to its use.

3. The rebreathing is objectionable for reasons stated before.

4. It is necessary to give a very strong ether vapor early to prevent a return of consciousness after the effects of the gas and rebreathing are gone. This sudden change to a strong administration of ether vapor often causes laryngeal spasm.

NITROUS OXID-OXYGEN-ETHER SEQUENCE METHOD.

This is also obtained by means of special apparatus (Gwathmey's, Cunningham's). No rebreathing is used. Anesthesia is begun by the administration of nitrous oxid mixed with oxygen in amounts varying from 5 to 15 per cent., according to the depth of anesthesia, the type and condition of the patient. As soon as consciousness is lost ether in gradually increasing amounts is given with the gas and oxygen. When complete ether narcosis is obtained (three to five minutes) the gas and oxygen is discontinued and air substituted.

Advantages. — 1. The nitrous oxid, oxygen-ether method has the advantages of abrogated induction period and the quick surgical anesthesia, the same as the nitrous oxid-ether method.

2. The oxygen mixed with the nitrous oxid prevents cyanosis, muscular rigidity, clonic spasms and other symptoms of asphyxiation, without destroying the anesthetic properties of nitrous oxid.

3. By mixing oxygen in the proper proportions with nitrous oxid, complete narcosis can be maintained indefinitely, and is used sufficiently long to permit complete ether narcosis to be established. Since the nitrous

oxid and oxygen are continued until complete etherization, there is then no return of the reflexes when air is substituted, and consequently no swallowing of the ether laden secretions. This prevention of swallowing eliminates a great factor in the production of post-anesthetic nausea and vomiting.

4. This longer administration of nitrous oxid and oxygen permits of a gradually increased and dilute administration of ether, which tends not to excite a hyper-secretion of mucus. Also, the patient is at no time overwhelmed with ether, as with the gas-ether method.

5. Nitrous oxid-oxygen-ether apparatus provides for the use of oxygen with the ether, if a condition arises which demands it. Oxygen administered with ether will quickly stop a clonic spasm without decreasing the amount of ether being used. This can not be done with air. Oxygen administered with ether gives a better narcosis and more perfect relaxation. It is often of decided advantage in patients of feeble vitality. The blood can safely take up much more ether if it is in a condition of hyperoxygenation.

6. The fact that no deaths have been reported from the use of this method speaks well for its safety.

Disadvantages.—1. The initial cost of this apparatus is considerable. Its use is somewhat more expensive than the gas-ether or closed methods; it is considerably less, however, than the open method.

2. The portability of apparatus for this method is less convenient.

3. Considerable skill is necessary for its use.

CONCLUSIONS.

The drop method is a very popular one. It is practically safe, while its simplicity makes it the method of choice for the inexperienced. Its shortcomings of perfection have been noted and they are sufficiently important to demand consideration. Modern anesthesia has already reached the stage where refinements of

methods are necessary, when skilled anesthetists are available. That a method possesses no serious obstacles is not enough. Modern surgeons and anesthetists demand a method of administering ether which overcomes certain minor and too often neglected objections, which are of more or less importance regarding the safety and pleasantness of ether anesthesia.

It may be ventured that hereafter general anesthesia will not be considered as a whole, but its various stages dealt with according to their obviously different requirements, and that this is to be accomplished by sequences of various anesthetics administered with an apparatus which is both accurate and practical, and by men whose entire time is given to this branch of the profession.

NITROUS OXID ANESTHESIA.

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Surgeons commonly agree that nitrous oxid is the safest general anesthetic known. Bevan estimates the death rate to be one in fifty thousand. Hewitt was able to collect records of seventeen deaths only from 1860 to 1900.

Ethyl chlorid has produced already thirty deaths in Great Britain alone.

Nitrous oxid is used by dentists, who employ it with great facility for the extraction of teeth. Thomas, of Philadelphia, has administered it 271,940 times with only one death, which occurred five hours after the administration, and was due to apoplexy. This case is included in Hewitt's report of seventeen fatalities.

Nitrous oxid has also been employed rather extensively to induce the anesthesia which is maintained later with

ether. This method contributes greatly to the comfort of the patient in avoiding the disagreeable sensations of "going under" ether. The Bennett gas-ether inhaler popularized the method, but the plan has not yet come into general use in America. It requires from one to four minutes only for complete anesthesia.

Nitrous oxid is undoubtedly a pleasant, safe and simple anesthetic for use in short minor operations, and were it not for the necessary apparatus it would enjoy a larger field of usefulness among surgeons. Aside from its use in very minor operations, such as slitting up sinuses, removing sutures, opening felons, abscesses and the like, Bevan has recommended that it be employed in short major operations.

Nitrous oxid is prepared commercially in a liquid state under high pressure in steel cylinders. When liberated for administration it is converted into a gaseous form. Each cylinder contains one hundred gallons of the gas, which should be kept in a cool place, because a high temperature causes it to explode. It can be obtained in two hundred and fifty and five hundred gallon cylinders also.

Nitrous oxid was discovered by Priestly in 1772, and its anesthetic properties were first satisfactorily demonstrated by Horace Wells in 1844. In 1868 Edmund Andrews, of Chicago, used it in several cases; he mixed it with air and obtained a longer and more satisfactory form of anesthesia than by nitrous oxid alone.[1]

The anesthesia obtained is not dependent on asphyxia; the gas possesses true and intrinsic anesthetic properties. It is irrespirable beyond a certain point. The surgeon who uses it should wait for stertorous breathing, but stop the administration of the gas when asphyxia appears. Anesthesia is induced in from 50 to 120 seconds, when, unless air is administered, symptoms of asphyxia appear.

1. Brit. Jour. Dent. Sc., 1869, p. 22.

The signs of nitrous oxid anesthesia are:

1. Quick, deep and stertorous respiration, slightly irregular.
2. Increased pulse rate.
3. Dilatation of the pupil.
4. Absence of eye reflexes.
5. Fixed eye balls.

The symptoms due to asphyxia are:

1. Cyanosis in varying degrees.
2. Jactitation (from anoxemia).
3. Clonic movements of the extremities.

If but little gas is administered these signs will be less prompt, and a stage of excitement will be marked by rapid movements of the limbs, and a mild talking delirium will supervene, from which circumstance the name of "laughing gas" was applied to the anesthetic. When proportionately too much gas is given, respiration is irregular, quick, and stertorous, the eyeballs are turned upward, with the lids widely open, and the pupils dilated. Cyanosis is then extreme, the pulse thready and rapid. Continuation of this condition, with exclusion of air, causes respiratory failure from muscular spasm, although the heart continues to beat. If the patient stops breathing, a gag should be inserted in his mouth, the tongue drawn forward, and artificial respiration should be done.

Recovery ensues usually in from twenty to sixty seconds after the discontinuance of administration of the gas, and the patient at once becomes conscious. There may be a slight headache and dizziness for a short time, but there is little or no postanesthetic nausea or vomiting. The actual period of anesthesia with a single administration of the gas lasts on an average for thirty seconds only. If, however, air or oxygen be mixed with the gas, or be given alternately with it, the anesthesia can be prolonged indefinitely. The asphyxial discoloration, jerking, and noisy respiration may be prevented

almost entirely by the careful employment of this measure.

Claude Lyons gave nitrous oxid mixed with 15 per cent. of oxygen to a dog for three consecutive days. Fifteen minutes after the discontinuation of the anesthesia the animal began to move, was able to stand and walk, obeyed commands after thirty-five minutes, and on the next day was well and hungry. Hewitt found that in sixty consecutive administrations of nitrous oxid the average number of respirations required to produce anesthesia was 29.10. The lowest number was six, and the highest seventy-two.

The time required to produce complete anesthesia is on an average about fifty-six seconds. This is a much lighter anesthesia than chloroform or ether anesthesia, and the patients are not so tranquil or so obliviously unconscious. The advent of stertor, and the slight clonic muscular twitching indicate the beginning of complete anesthesia. The surgeon may begin to operate when stertor occurs. If he begins sooner and while the patient is in an imperfect state of unconsciousness, there may be a great deal of spasm and jerking. The operation should be discontinued if there is marked weakness of the pulse or respiration, or if there be vomiting.

The statement is made that no case of primary failure of the circulation has been observed with the use of nitrous oxid, but in every recorded case of nitrous oxid death there has been marked disturbance of respiration.

The feasibility and efficacy of nitrous oxid anesthesia carried on for some time is of great interest to the surgeon. Kelly[2] has removed the appendix several times "under gas," and reports one case of chronic nephritis, with albumin, of thirty years duration, for which he operated with the use of nitrous oxid. The operation lasted one hour and six minutes with complete uncon-

2. Diseases of the Vermiform Appendix, p. 517.

sciousness of the patient. The issue was successful, and there was no untoward effect, except that the patient slept almost continuously for the first week subsequently.

There have been no deaths reported from the administration of nitrous oxid and oxygen. In favorable subjects normal sleep is closely imitated.

There are many forms of apparatus by which nitrous oxid can be administrated with air or oxygen. Bennett's gas inhaler, Hewitt's apparatus, Herbert Paterson's in England, and those manufactured by Clark, of Chicago, and by the S. S. White Dental Company, are the ones usually employed. Directions for the employment of each accompany the apparatus. It is best to administer the gas and air at first concurrently, rather than alternately. Hewitt states that 14 to 18 per cent. of air is the most suitable mixture for men, and 18 to 22 per cent. of air for women and children. With over 30 per cent. of air anesthesia can not be produced. As a matter of actual experience, the question is simply one of keeping the patient sufficiently anesthetized with enough air to prevent asphyxia. A moderately snoring, regular respiration, with slight duskiness of the countenance must be maintained. The air can be administered with the gas or one may change to pure gas as occasion demands.

The occasional endeavor has been made in this country during the last third of a century to use nitrous oxid in surgical operations, but the profession have not gotten further than to employ it in short operations requiring from one to ten minutes, for those cases in which ether or chloroform are contraindicated. Bevan[3] urged its employment on account of its greater safety, absence from unpleasant symptoms, the little or no resulting nausea, and for its rapidity of action. He claims that it is the anesthetic of choice for the reduc-

3. The Journal A. M. A., 1907, xlix, 197.

tion of fractures and dislocations; for the opening of felons; for breaking up adhesions in joints; for draining empyemas and lung abscesses; for exploratory laparotomies and gall bladder work; for nephrotomy, nephrectomy, and nephrolithotomy; for bladder work such as suprapubic cystotomy for stone, and suprapubic prostatectomy; for draining appendiceal abscesses; for colostomy, gastrostomy, and enterostomy; for the repair of typhoid perforations and for gastric and duodenal ulcers; in hernia operations, especially for the relief of strangulated hernia, for varicocele, and open operations for hydrocele; in castrations; in amputations, except at the largest joints; and in removing such growths as fatty tumors. It was used seventy-seven times at the Presbyterian Hospital in Chicago from Oct. 1, 1907, to May 1, 1907, as against 214 ether administrations. He says further that it can not well be employed in operations on the perineum, such as for hemorrhoids, because when so anesthetized the patient has a tendency to straighten out his limbs. When there is complete muscular relaxation, the surgeon must view calmly the livid color of the patient's face, the dark blood in the wound, and the occasional talking and moving of the patient.

Nitrous oxid can be employed in operations lasting for from thirty minutes to an hour, and has been administered for as long as two hours. It can be employed with advantage in about one-third of all our surgical work. It should be given with the patient in the position requisite for the operation, i.e., Sims, lithotomy, etc., after the field of operation has been prepared and everything has been made ready for the incision. If the patient has a heavy beard, the oval under the face-piece of the inhaler should be covered with several layers of moist gauze, that the mask may fit closely enough to exclude air at that point.

The advantages of nitrous oxid as an anesthetic are:

1. Quickness of action.

2. Absence of uncomfortable sensations to the patient.

3. Almost immediate recovery.

4. Absence of lung complications.

5. Absence of danger to the kidneys.

6. Abscess of postanesthetic vomiting.

7. Improbability of subsequent fatty degeneration of the kidneys, liver and heart. It is to be preferred especially when there is a disease of those three great organs, and for the patients who have previously had unpleasant experiences with the other anesthetics—such experiences as aggravated postoperative vomiting.

Nitrous oxid should be administered by an expert anesthetist only.

The disadvantages of nitrous oxid as an anesthetic are:

1. It is not suitable for fat, plethoric and alcoholic patients.

2. Its zone of anesthesia is within somewhat narrow limits.

3. Slight lividity and occasional talking occur.

4. We can not always secure the requisite skill for its successful administration, nor the required quantity of gas, and the proper apparatus.

5. The cost is not inconsiderable.

From one to two cylinders of one hundred gallons each are needed for an hour's administration.

Contraindications for its use are:

1. It should not be employed for patients with dilated hearts or for those with extremely bad hearts, whether with valvular or myocardial disease.

2. It is not suitable for young children on account of their fear of the mask, etc.

3. It should not be used in case of narrow or abnormal air passages, of enlarged lymph nodes, goiters, or enlarged tonsils and adenoids.

I have employed nitrous oxid with air as an anesthetic twenty-six times from May 15 to August 15. The list of operations comprises minor operations lasting from four to fifteen minutes, and in three major

operations: recurrent appendicitis, a 40-pound ovarian cyst, and a suprapubic cystotomy for stone in a man 80 years of age. The duration of the anesthesia in these three cases was ten, fourteen and twenty-five minutes, respectively. The induction is painless and prompt, the recovery almost synchronous with the withdrawal of the mask. The patients leave the operating room, conscious, and in smiling contrast to the narcoses of other general anesthetics.

CHLOROFORM ANESTHESIA.

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Since the introduction of choloroform by Sir James Y. Simpson, in 1864, it has remained one of the most important anesthetics. Following the historic death of Hannah Greer, there have been many other deaths which indicate the danger of this drug. It is still, however, the anesthetic of choice in Scotland, in parts of England, and on the continent of Europe. For general surgical practice, however, the experience of the last fifty years has shown ether to be much safer, and it is the routine anesthetic employed by surgeons in America. Chloroform, unfortunately, is still used by many for minor surgical work, because of its ease of administration and its rapid action. Healthy obstetric patients take choloroform in small quantities and intermittently with safety, and this fact has begotten an impression that it is safe also in continuous administration for surgical operations, undertaken for the cure of pathologic conditions. Unfortunately, the majority of anesthetics are given by persons who are not skilled anesthetists. Indeed, Hewitt says that the risks of general anesthesia are neither in the patient nor

in the anesthetic, but in the anesthetist. This is an important fact in the problem of anesthesia. Deaths from chloroform are from simple over-dosage, in the great majority of instances. Chloroform is so insidious, it acts so rapidly, and kills so quickly in the very beginning of its administration, that there is little time for the patient's resuscitation. Ether being slow in its action and in the production of dangerous symptoms gives ample opportunity for their recognition and for efforts at resuscitation.

Out of the whole chloroform and ether controversy there comes the knowledge that for general work ether is approximately five times as safe as chloroform. Even if chloroform, in the hands of an expert, can be rendered free from many of its dangers, ether can be rendered more safe by scientific administration. There are some conditions, however, in which we recommend chloroform on account of its special properties:

1. In the treatment of certain convulsive seizures.
2. In obstetrical practice.
3. In the presence of kidney lesions.
4. In elderly persons, with dyspnea.
5. In operations on the brain it is preferred by some experienced surgeons.
6. In obstructed conditions of the trachea, esophagus, and larynx.
7. In deep cellulitis of the neck.

Chloroform is particularly to be avoided:

1. In all conditions of heart weakness.
2. In all operations requiring the semi-recumbent or sitting posture, particularly in dental operations.
3. In minor surgical operations.

Physiology.—Chloroform is taken up mainly by the red blood corpuscles, and is said by Moore and Roaf[1] to form unstable and dissociable compounds with the protoplasm of the blood and tissues.

1. Proc. Roy. Soc., lxxiii, 382.

1. It is a cardiac depressant acting on the inhibitory mechanism of the heart and producing syncope from dilatation of the capillaries through the vasomotor system. In fatal syncope the dilatation of the capillaries is so marked that a large proportion of the blood leaves the brain and great organs, and the patient is bled to death in his own capillaries. Chloroform inhibits the heart muscle also through the coronary arteries.

It has been proved that when a diluted concentration of chloroform is allowed to perfuse the tissues of an isolated heart, the contractions of that organ will be diminished, and that when the concentration of chloroform is great, the heart stops. Sherrington and Sowton[2] have shown through animal experimentation, when the heart beat is pressed to extinction by chloroform, that after one-half hour the beat can be re-established in a few seconds by allowing fresh blood instead of the chloroform-laden fluid to flow through the coronary vessels. The prolonged action of chloroform-laden blood results in paralysis of the respiratory center. Indeed, failure of respiration has usually been assigned as the first danger of chloroform, and, second, failure of the heart.

2. Cases in which cardiac failure apparently occurred first, as manifested by cyanosis while gasping still continued, have been reported. Sir Lauder Brunton thinks respiratory paralysis occurs first, and the Hyderabad Commission reported that respiratory shock seemed to be primary, and cardiac paralysis secondary. Much controversy has arisen among physiologists over this point, and many facts adduced show that the failure of the heart is the real danger, while Hewitt thinks that the modern consensus of opinion establishes the heart paralysis as the chief event. In all cases there is a considerable fall in the blood pressure.

Death is stated to occur from vagus excitability (Embley). This is illustrated in the so-called "fright

2. Id., lxxii, 86.

syncope," which sometimes occurs when the first operative incision is made before the patient is completely unconscious. We conclude that all of the accidents of chloroform are due to over-dosage. That this is so is shown by laboratory experiments. It is a notorious fact that clinically the majority of deaths from chloroform occur in the early stages of anesthesia, and after a "few drops have been sprinkled on the cloth." Such deaths usually occur in the first or so-called stage of excitement. During the struggles of the patient he holds his breath, the pulmonary blood pressure is consequently raised, and the venous system is congested. If the anesthetist continues the administration in an effort to "get the patient under," suddenly a deep inspiration carries a densely concentrated vapor to the lungs. Blood loaded with chloroform enters the coronary arteries and causes instantaneous paralysis of the heart muscle. This explains the sudden deaths. A semi-recumbent or upright position facilitates this action of chloroform, and has doubtless contributed to the dentist-chair chloroform deaths. The only accidental chloroform death of an animal which occurred in Professor Waller's laboratory[3] took place when, the animal being anesthetized and ready for the experiment, the operator was called away for a more urgent matter. The animal began to come out from the anesthesia, and was re-anesthetized by a few drops of chloroform on a cloth, which caused a sudden arrest of the heart and respiration. Artificial respiration failed to restore it. This incident corresponds with the experience so dreaded by the surgeon.

Advantage was taken of the accident. By the aid of a densimeter the procedure was imitated with another dog, the experimenter using the same piece of cloth with chloroform sprinkled on it in about the same quantity, wrapped around the animal's head, as when its fellow was fatally anesthetized. The percentage of chloroform

3. Lancet, Lond., 1903, p. 1484.

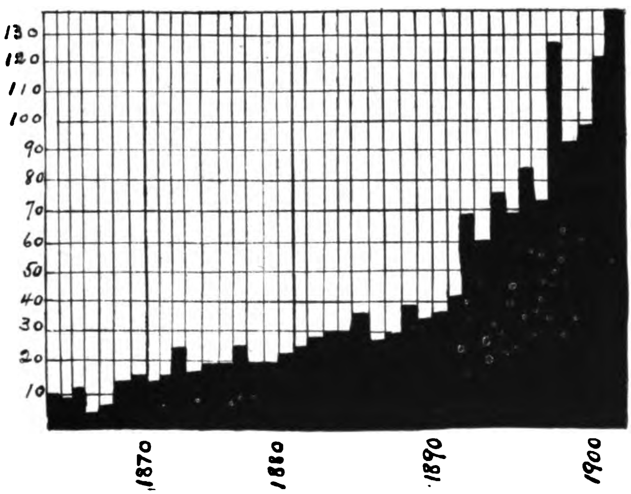

Diagram of the annual number of deaths from anesthetics in England in the years 1863 to 1901. Constructed from the returns of the Registrar-General.

vapor in the fatal case was found to be 11.2. The second and harmless trial with the cloth showed a percentage of 2.4. A third experiment with the cloth held away a considerable distance gave a percentage of 1.2.; so that it was demonstrated that the Edinburgh method of "plenty of chloroform with plenty of air" is safe, because the mask is held so far from the patient's face that practically only a 2 per cent. vapor is inhaled. A closely fitting mask, therefore, should not be used, even if the drug is given only drop by drop.

Preparation.—The preparation for the administration of chloroform is identical with that for ether, and may be summarized as follows:

1. Make a careful physical examination with special reference to the lungs, the kidneys, and the heart. In the urinary examination include tests for acetone and diacetic acid. Empty the stomach, bowels and bladder.

2. The mouth should be cleared of artificial teeth or any other foreign substance.

3. The teeth should be carefully cleaned, and the mouth and throat rinsed by some aromatic antiseptic solution. Many cases of aspiration pneumonia come from oral sepsis.

4. The nose should be cleansed by blowing and by insufflation.

5. The clothing should be loosened about the throat and waist.

6. The administration should invariably be made with the patient in the recumbent posture.

7. Tongue-forceps, mouth-gag, hypodermic syringe, stimulants, adrenalin solution, and an infusion canula and saline solution should be at hand.

8. The anesthetic is preferably administered with the patient on the operating table. Deaths have been reported at the moment of lifting the patient on to the table.[4]

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4. Lancet, Lond., Sept. 17, 1904, p. 842.

It is desirable and convenient to prepare the field of operation while the patient is taking the anesthetic, as this distracts his attention and saves his taking the additional amount of anesthetic necessary to cover the period of cleansing the field after unconsciousness has been established. The patient should be well wrapped in blankets, care being exercised that no chilling occurs. It is convenient for the anesthetist at the conclusion of the operation to complete his notes of the anesthetization on slips which should be filed for permanent record.

Chloroform should be kept in small brown bottles, tightly corked and in a cool place. It should not be used in a room in which there is an open flame, as hydrochloric acid is given off into the atmosphere, which greatly irritates the respiratory tracts of persons in the room.

Administration.—Vaselin or lanolin should be applied to the patient's face to prevent the contact of the drug and consequent blistering of the skin. An Esmarch's inhaler or a Skinner's mask are the most convenient and useful forms of apparatus for the simple uncomplicated administration of chloroform. The mask should be covered with a layer of flannel. Close fabrics result in less concentration of vapor than open-meshed fabrics, and in a less-uniformly sustained concentration. Legge Symes found that the chloroform drawn from under Skinner's mask showed the proper concentration and was more certain and uniformly sustained by the drop method than by the douche. A fall in frequency and depth of the patient's respirations may lead to inhalation of dangerously concentrated vapor, even when the amount of chloroform is apparently not excessive.[5]

The drug may be administered from a drop bottle or wicked out in drops with a wisp of cotton in a slit in the cork of the original bottle. Anderson suggests that a small aspirating needle be inserted through the

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5. Lancet, Lond., July 4, 1904, p. 82.

cork, the obturator withdrawn and the drug dropped therefrom. Waller estimates that an average anesthetization should be induced in ten minutes, with less than a drachm of chloroform.

The administration should begin with the mask held five inches from the face and the evaporating plane, and should never be closer than two inches. The drug should be delivered drop by drop, approximately one drop with each inspiration. Syme found experimentally that 66 drops per minute (equalling 1 c.c.), diluted in 350 c.c. of air aspirated on an average of 20 aspirations per minute, give a vapor of 1.4 per cent. concentration. This is about the proper concentration with which to begin, as advised by the chloroform commission appointed by the British Medical Association in 1904. Waller estimates that the normal maximum concentration compatable with the effective induction of anesthesia, with freedom from unjustifiable danger, is 2 per cent.

At the outset, the patient should be reassured and instructed to breathe naturally. At the stage of excitement, which may appear in from three to six minutes, care should be exercised that too much chloroform is not given when respiration is checked. If the patient begins to struggle, the chloroform should not be pushed as with ether, but should be discontinued immediately and fresh air administered. It is in struggling that the breath is held and the absorption of chloroform already in the lungs occurs, while with the next full inhalation an overdose is frequently obtained unless the administration is temporarily suspended while the patient is not breathing.

After the stage of excitement is over the drop is continued with just enough frequency to keep the patient in a tranquil state of anesthetization. The sluggish, mobile, contracted pupil is said by Hewitt to be the desirable and safe guide by which to judge the patient's condition. Roughly speaking, a moist spot on the flan-

nel the size of a 25 cent piece is said to be about the proper amount of chloroform to exhibit. The angle of the jaw can be held gently forward by the anesthetist, especially if there is any interference with free air passage. The temporal or facial pulse can be felt with the fingers of the hand which holds the mask over the face.

Syme's rule, "watch the respiration," is imperative. If a beginner will rivet his attention on the breathing and note its slightest alteration as the first danger signal, he will do better than by attempting to observe the many things which he is often admonished to notice. Observation of the color of the lips and of the pupils will soon become a part of the general mental vigilance which he keeps over his patient. A patient with rosy cheeks or lips is in no danger.

It is imperative for the anesthetist to watch, first, the respiration; second, the reflexes; third, the circulation; always the patient, but never the operation.

Signs of Surgical Anesthesia:

1. Regular, rhythmic, slightly stertorous, and somewhat increased respiration.
2. Contracted pupil.
3. Slow, even, and rather full pulse.
4. Absence of eye reflexes.
5. Relaxation of the muscular system.

Signs of "Coming Out:"

1. Return of pupillary reaction.
2. Conjunctival and corneal reflexes.
3. Swallowing.
4. Attempts at retching and vomiting.
5. Shallow, non-stertorous and slow respiration.

Danger Signals:

1. Sudden pupillary dilatation.
2. Weak, thready pulse.
3. Short, irregular, gasping respiration.
4. Sudden pallor, or slight duskiness merging into cyanosis.
5. Cessation of breathing.
6. Intermittent pulse.
7. Stopping of the heart.

Resuscitation:

1. Remove the mask.

2. Lower the head. If dealing with a child, invert and suspend him by the heels; if with an adult, employ the extreme Trendelenburg position.

3. Open the mouth with a gag.

4. Seize the tongue and pull it forward.

5. Inject one or two c.c. of adrenalin (1-1,000), with salt solution, through a canula into an artery, toward the heart.

6. Employ Sylvester's method of artificial respiration, systematically performed, and kept up unremittingly for at least thirty minutes.

The latter is the most desirable and most generally applicable of all methods to resuscitate in chloroform syncope. The arms of the patient, grasped at his elbows, should be compressed firmly against his lateral chest walls, and then drawn back to full extension for inspiration; then, slowly, they should be pushed down, recompressing the chest. This cycle of respiration should simulate exactly normal respiration; the work should not be performed frantically, or with greater rapidity than to induce eighteen respirations per minute. Cases have been reported in which recovery ensued after one and one-half hours of artificial respiration. In one instance there was no sign of life for fifty-five minutes.[6]

Unfortunately, chloroform collapse is beyond the help of the so-called heart stimulants. Hypodermics are valueless, and their repeated and frenzied administration should be discouraged. One hypodermic of strychnin is, perhaps, all that is permissible, and certainly all that is of value.

Some interesting studies in experimental resuscitation have been made by Crile and Dolley.[7] By cardiac massage alone animals were rarely resuscitated at any time after quiescence of the circulation and respiration; by combining either direct or indirect cardiac massage with artificial respiration and head downward posture a certain percentage of the animals were recovered after the

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6. Lancet, Lond., May 16, 1903, p. 1367; also Brit. Med. Jour., June 20, 1903.

7. Jour. Exper. Med., viii, No. 6, Dec. 21, 1906.

lapse of from one to three minutes. The results, however, were quite uncertain, and in the case of death from chloroform, recovery was the exception. . . . In the majority of these failures autopsy showed the heart to be in a state of marked distention indicating complete cardiac paralysis. . . . Not infrequently, when results were delayed, the acute cardiac dilatation was partly reduced by venesection, and by placing the dog in the inclined, head-up posture, thereby partly relieving the heart of its over-distention.

It was believed that by clinically raising the coronary pressure which inaugurates the heart-beat, as has been proved by Sollmann and others. resuscitation could be effected, just as when the excised heart has been experimentally made to beat again. Crile had already established the value of adrenalin in raising the blood pressure. It acts on the vascular walls of the blood vessels themselves. If, however, it was introduced in the venous circulation, the heart could not be influenced, and, in fact, the blood pressure could not be quickly increased, because the adrenalin had to traverse the right heart and the lungs before reaching the left side of the heart whence it went into the coronary arteries through the aorta. As a mater of fact, there is an accumulation of adrenalin solution in the dilated and paralyzed heart, and for this there is no succor. In Crile's later experience, therefore, the solution of adrenalin in salt solution was injected into the artery toward the heart, and at once it increased arterial pressure.

The conclusions which he drew from these experiments for the purpose of this study are as follows: Animals, after death from chloroform, up to five minutes are uniformly and readily resuscitated, provided the full technic be applied—1 or 2 c.c. of 1 to 1,000 adrenalin solution injected by the hypodermic syringe into the rubber tubing of the transfusion apparatus while the salt solution is flowing through a canula into

an artery, and directed toward the heart. The carotid is preferred in animal experimentation, but with human beings any artery (the radial) may be selected. Up to ten minutes, in animal experiments, there is an occasional failure to resuscitate; beyond ten minutes consciousness is rarely restored, and the success of efforts at resuscitation diminishes with the lapse of time; after twenty-three minutes in adult dogs and thirty-five minutes in puppies complete return of the circulation is not accomplished. Attempts at resuscitation, if successful, occur within one minute after the administration of adrenalin in the majority of instances; it rarely occurs after an interval greater than three minutes.

In view of these experiments every operating room in which chloroform is administered should be equipped with the paraphernalia for the use of adrenalin and salt infusion.

Crile advises against open cardiac massage, which induces cardiac trauma. Massage of the motionless heart through the diaphragm, when operating in the abdomen, has been recommended in order to express the chloroform-impregnated blood. Dobson has deliberately opened the abdomen for this purpose, and successfully in a child in syncope.[8]

Percentages.—Perhaps the most intelligent addition to our knowledge of chloroform, aside from the very elaborate physiologic experiments which have been made in the last few years—and possibly as a direct outcome of these, has been the determination of the exact percentages of chloroform vapor in the dosage, and the invention of apparatus for the regulation of that dose. It is more essential to measure the dose of chloroform precisely than of any other anesthetic. While we have been estimating it roughly and empirically for half a century, only in the last four years have we succeeded in perfecting our measurements.

8. Lancet, Lond., Nov. 30, 1907, p. 1537.

Snow, in 1849, employed an inhaler computed to supply a vapor of 5 per cent. at 60 F. Clover's inhaler was made on a similar principle. Junker devised an apparatus which had the same purpose in view. His apparatus has been modified by Krohne, as well as by Hewitt, and is the simplest of the percentage devices. Physiologists find that animals can be kept completely anesthetized for twelve hours under a bell jar connected with the Dubois pump, which delivers a 2 per cent. chloroform vapor. Waller says he never lost an animal in the laboratory when using this method. The importance of the actual arithmetical percentage, its recognition and conception in figures, is shown by the experiment of an animal completely and safely anesthetized in four minutes with a 3 per cent. chloroform vapor, and the same animal subsequently killed by a three minute anesthetization with 13.2 per cent. vapor.[9]

Deaths that still occur must be ascribed to ignorance of the toxicity of the drug and the exact amount which is necessary an anesthesia. We have hitherto been unable to compute how much in excess of that necessary amount the patient is really getting. Our great danger is in cramming the towel or inhaler close down over the patient. This crowding is shown to give a 10 per cent. chloroform vapor and upward, which is five times the limit of safety.

In 1904 Vernon Harcourt devised an apparatus which seems to be a perfect regulator. Collingwood, Levy and Waller, in working along the same lines, made similar chloroform inhalers in 1904. Levy claims to do away with the objection which has been urged against Harcourt's apparatus (that shaking the apparatus greatly increases the vapor) by fixing his apparatus rigidly to the table. He also claims to prevent fluctuation in the strength of the vapor caused by variation in the character of respiration.

9. Trans. Soc. of Anesthetists, v., p. 82.

Dubois' apparatus establishes a continuous flow of air containing chloroform vapor of 1.2, 1.6 and 2 per cent. independent of any suction effort on the part of the patient. Dubois' apparatus is worked by turning the handle six times a minute, when each revolution delivers four liters of the chloroform and air mixture. Waller devised a wick-vaporizer energized by a foot-bellows for the same purpose. This is accurate, simple and satisfactory.

All of these devices are unquestionably on the right lines, and while many practical objections have been urged against them, they are unquestionably correct theoretically. They are not intended to do away with the skill of the anesthetist. Most of them allow the vapor to be increased to 4 per cent. Critics have objected that it requires about ten minutes thus to induce anesthesia, but this should not be a serious objection. If chloroform vapor, in clinically estimated and varying percentages, is safe in the hands of an expert, an accurate percentage is certainly no less safe. Conversely an automatically regulated percentage with which it is well-nigh impossible to produce over-dosage, is certainly less dangerous when combined with skilled employment.

The objection to the Dubois apparatus is its cost and weight, and the fact that it requires two persons to use it. We hope that some simple form of apparatus, if it has not already been devised, may be produced. Such an apparatus would render anesthesia an exact science, as well as an art.

Hepatic Toxemia.—A. D. Bevan and H. B. Favill have shown[10] that cases of late death after operations under chloroform, formerly ascribed to late shock, sepsis, uremia, fat embolism, meningitis, etc., developing in from ten to one hundred and fifty hours, with vomiting, restlessness, delirium, convulsions, coma, Cheyne-Stokes

10. The Journal A. M. A., Sept. 2, 1905, p. 694.

respiration, cyanosis and icterus, are due to hepatic toxemia. This is caused by the destruction by chloroform (by ether in a slight degree only) of the liver cells especially, as well as other structures. The toxemia is in direct proportion to the quantity and duration of the anesthetic.

The predisposing causes are alcohol, lead, carbolic acid, mercurial and iodoform intoxications, homesickness, fright, change of food, intestinal fermentation and putrefaction, infantile paralysis, starvation, sepsis, pregnancy in the presence of a dead fetus, a gangrenous mass, diabetes, carcinoma, anemic changes from any cause, and hemorrhage. Mild cases of toxemia, with evanescent jaundice, recover.

The poisoning is due undoubtedly to liver insufficiencv; toxins develop therefore. The condition is similar to that of phosphorous poisoning. There is an acute fatty degeneration of the liver and as by-products there are acetone and diacetic acid in the urine. The danger of this hepatic toxemia renders chloroform hazardous in the presence of diabetes, sepsis, starvation, hemorrhage, intoxication from dead material, fatty degeneration after infantile paralysis, and lesions of the liver. Bevan and Favill condemn chloroform, especially in long (two hour) operations on children.

Brackett reported a series of fatal cases of acetonuria after operations. The symptoms were sweetish breath, vomiting, weak and rapid pulse, exceedingly high temperature, delirium and death. Some cases without operation, with mild symptoms of acetonuria, recover. Many cases with sweet odor of the breath, vomiting, prostration, and recovery were noted. Of the fatal cases necropsy showed fatty degeneration of the liver, kidneys and muscles. Guthrie[11] reported nine cases of death from chloroform in children with fatty livers, which he thought due to acid intoxication. Bicarbonate

11. Lancet, Lond., July 4, 1903.

of soda seems valuable in this acidosis. McArthur, of Melbourne, advises the examination of the urine for diacetic acid and acetone, as a routine measure, both before and after the use of chloroform.

RECOMMENDATIONS.

1. Further investigation in physiologic laboratories of the action and safe dosage of chloroform.
2. Further experimentation in the perfection of an apparatus for the dosimetric administration of chloroform.
3. That in all hospitals a member of the staff be appointed as the head of the anesthesia department, who should personally supervise the administration of anesthetics, as far as possible, and be responsible for the instruction of those to whom their administration is entrusted.
4. Tutelage of undergraduate students in the practical administration of all anesthetics.

LOCAL ANESTHESIA.

EXTENT TO WHICH LOCAL ANESTHESIA HAS BEEN ADOPTED IN AMERICA.

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Except for strictly minor operations, the use of local anesthesia in America is limited to a few clinics, though its adoption abroad is far more general. This limitation may be due, in part, to American hurry, but more probably to inexperience in the method and a certain deep-rooted fear of poisoning, traceable to the days of strong cocain solutions.

To those surgeons who have persisted in its use and have become familiar with the technic its field is con-

stantly broadening. In the clinics of Matas in New Orleans, of Crile in Cleveland and in a few other places local anesthesia is employed extensively. Bodine of New York reports the use of local anesthesia for all hernia operations, amounting to many hundreds in the last few years. From numerous places come reports of its satisfactory application in rectal work and in operations on the nose and throat. In my own practice its use is increasing with experience, and at the present time fully 50 per cent. of my operations are done without the aid of general anesthesia. This increase in its use is attributed to familiarity with the methods of application.

ADVANTAGES AND DISADVANTAGES.

Danger to life, as far as the anesthetic is concerned, is practically not to be considered. Postoperative renal and pulmonary complications are reduced to a minimum, and the small but certain danger of general narcosis, as well as its disagreeable features are eliminated.

It can not be denied that pulmonary complications may occur. In the experience of the writer, however, these have never been encountered. Postoperative depression and the consequent danger of shock is less, so that age and lesions of the heart or kidneys do not have the same importance as determining factors in the prevention or delaying of operations. The necessarily careful handling of tissues is an additional factor in securing rapid healing and in the prevention of infection. In general, the great amount of time necessary for operations under local anesthesia, and its employment in certain regions of the body only, represent its limitations.

SCOPE.

In minor procedures its application is unchallenged, and such small operations, as the opening of abscesses, or the amputation of fingers, toes, etc., so often done without anesthesia, may be rendered painless by a small

amount of cocain properly placed. In general, when the field of operation can be rendered insensitive, local anesthesia may be used. Practically all amputations in the course of limbs may be accomplished, and in many regions the wiring of fractures or the removal of diseased bone may be painlessly done. In the abdomen, as an aid to exploration, it is quite satisfactory, and has accomplished a great deal in diminishing our fear of opening the abdomen in such conditions as typhoid perforation. For operating on organs in apposition with the abdominal wall, and requiring little retraction, local anesthesia is sufficient.

The removal of the appendix in the interval is usually an easy and painless procedure in the absence of adhesions. Its usefulness in the abdomen is limited by the amount of retraction and dragging on the parietal peritoneum necessary for the accomplishment of the desired operative procedure. All forms of hernia are amenable to its use. In no case of inguinal hernia is a general anesthetic necessary, and with strangulation, local anesthesia is almost imperative. All operations about the scrotal and inguinal regions can be done with absolute freedom from pain. The character of the patient is a small factor. Children are necessarily difficult subjects, but with experience the "nervous patient" as a contraindication has practically disappeared. In extensive dissection for malignant disease, local anesthesia should not be considered.

ANESTHETIZING SUBSTANCES AND THEIR PREPARATION.

Since the introduction of cocain, in 1884, numerous local anesthetics have been brought forward. While in individual clinics many of these are still in use, cocain and eucain β alone have held general favor. It seems to me that the danger of poisoning from cocain has been greatly over-rated, and with the adoption of adrenalin and the use of weak solutions, fear of poisoning scarcely deserves consideration. The advantages claimed for eucain are that it is only one-fourth as toxic

as cocain, and that its solutions stand boiling. Its disadvantages are that anesthesia is obtained by it more slowly and does not last as long as that from cocain. After an extensive use of cocain I have no fault to find with it, and I consider it, with proper precautions, the most satisfactory of all local anesthetics.

PREPARATION OF SOLUTIONS.

The solution for injection should fill the following conditions: (a) It should be isotonic with the fluid of of the body tissues; (b) it should be sterile; (c) it should contain a definite amount of the anesthetizing substance; (d) it should be so constituted as to obtain the greatest action with the least danger of absorption.

Such a solution is most conveniently prepared by the use of tablets, containing cocain hydrochlorate 0.05 gm. and adrenalin 0.00016 gm. These tablets are sterilized in dry heat at 80 C. for an hour on each of three successive days, and are dissolved in sterile normal salt solution immediately before the operation. A fresh solution, isotonic with the blood, is thus obtained, containing a definite amount of cocain, while through its adrenalin content it limits absorption. One tablet dissolved in 50 c.c. of salt solution yields a 1:1000 solution of cocain, and one tablet in 5 c.c. makes a 1 per cent. solution. These solutions may be diluted for special use by the addition of salt solution. These tablets are in the American market and have proved most satisfactory to me. I offer them as the most satisfactory vehicle for the preparation of solutions for local anesthesia.

TECHNIC.

Success with local anesthesia depends largely on experience and practice, as well as on the patience of the operator; but especially on his minute knowledge of sensory nerve distribution, so that he may surely make the application where it will do the most good, with the avoidance of painful manipulations.

The methods of application, briefly, are: (1) Surface applications; (2) infiltration; (3) nerve blocking through endoneural and purineural injections. Each of these has its special applications, or all of them may be combined in one operation.

In addition to the purely local methods the combination of local with general anesthesia forms a most important addition to our anesthetizing methods.

In the general technic and preparation I wish to emphasize the importance of the mental attitude of the patient, obtained by a small preliminary dose of morphia; the mutual confidence between patient and surgeon; the quiet conduct of the operating room; the avoidance of haste, and the careful handling of tissues on the part of the surgeon.

In regard to the methods of injection, the operator's individual choice is the best criterion. In my own work the small hypodermic syringe has been sufficient. Other surgeons prefer larger syringes, and more complicated needles. For the accomplishment of massive infiltration, the pressure apparatus of Matas has proved most satisfactory. It has been found by experience that very weak solutions of cocain, combined with adrenalin, will accomplish with a minimum of danger all that can be obtained by the use of stronger solutions. For nerve blocking a 0.5 to 1 per cent. solution of cocain is quite strong enough. For ordinary infiltration a 1 to 1,000 solution of cocain suffices, and for massive infiltration a 1 to 3,000 solution of cocain is ample. Eucain solutions may be of practically the same strength.

CONCLUSIONS.

1. Whereas I do not submit local anesthesia as a substitute for general anesthesia, I do believe it has a definite field of usefulness, and that this field may be increased by familiarity with modern methods and experience in their use.

2. Whereas the danger of general narcosis may be small under the best conditions, that from local anesthesia is always less.

3. Whereas in individual hands one or other of the newer anesthetics may possess certain advantages, cocain and eucain have proved most satisfactory in the long run.

4. The danger of poisoning has been practically eliminated by the use of weak solutions in combination with adrenalin.

5. The methods of application may be classified as: (a) Surface application; (b) infiltration; (c) nerve blocking by endoneural and perineural injections; (d) these methods used singly or in combination, or any or all of them combined with more or less general anesthesia.

6. Success depends on the temperament and patience of the operator, his familiarity with sensory nerve distribution and his experience in the use of local methods.

SPECIAL METHODS OF ANESTHESIA.

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In certain operations the selection of the anesthetic agents and the method of their administration is of such importance that the success of the operation may be said to depend on the way in which the anesthesia is conducted. This is particularly true in operations about the head and neck in which, in order to do his best work the surgeon should have a clear field and be interfered with as little as possible by the anesthetist.

This statement holds true, also, of operations on the thoracic cavity, empyema or abscess of the lung; in operations on the kidney, with or without an existing neph-

ritis; in certain grave abdominal operations, especially in those with peritonitis and vomiting; and in bladder and prostate operations on old men.

In such cases the anesthetist should always see his patient the day before operation, and after a careful examination (to study especially the breathing) should determine what agents and methods he is to use. Besides being governed in his selection by the ordinary considerations of sex, age, temperament, condition of lungs, heart and kidneys, he must plan the anesthesia so as to interfere with the surgeon as little as necessary, and help him as much as possible.

OPERATIONS ON THE HEAD AND NECK.

This is a broad field and includes: brain operations, eye and ear operations, nose and throat operations (including the antrum and frontal sinus), resection of the lower jaw, extirpation of the tongue, extirpation of goiters, removal of enlarged lymph nodes, operations on the larynx, esophagus, etc.

Generally speaking, it is important in all these operations (except in cerebral operations), to administer relatively large doses of morphin and atropin half an hour or twenty minutes before the operation. These doses should be as large as possible, for women, morphin 1/6 to 1/4 gr., atropin 1/50 to 1/100 gr.; for men, morphin 1/4 to 1/2 gr., atropin 1/100 gr., will not usually be found too large. This is particularly important if we are depending on simple inhalation anesthesia, because morphin intensifies and prolongs in a marked degree the anesthetic action of either chloroform or ether, so that after anesthesia is complete, patients will often remain in a condition to continue the operation in twenty or thirty minutes after the removal of the inhaler.

If rectal anesthesia is used the morphin and atropin may be omitted or administered in smaller doses, according to the patient's characteristics.

The methods which may be used for anesthetizing

in operations on the head and neck are: 1. Simple inhalation anesthesia. 2. Anesthesia by Greene's thermo-ether inhaler. 3. Scopolamin-morphin anesthesia. 4. Rectal anesthesia. 5. Crile's intubation of the pharynx.

Simple inhalation anesthesia by ether, chloroform, or mixtures of the two is still preferred for these operations by many surgeons. If the patient is well narcotized at first by morphin and atropin, and then deeply etherized, a very long available anesthesia[1] can often be produced. It is not uncommon to obtain an available anesthesia of from ten to thirty minutes and even longer. When the available anesthesia has passed, from five to eight minutes is usually ample time in which again to put the patient deeply under the anesthetic.

The disadvantages of this method are, (1) that available anesthesia varies a great deal in different patients and may be too short to be of any use, and (2) that by the deep anesthesia produced by both morphin and ether, dangerous respiratory depression may result.

In major surgery reported results seem to show that often it is dangerous and sometimes not successful—inhalation anesthesia often having to be used to keep the patient quiet enough to operate on him.

Recovery from the anesthesia is usually long delayed, and the method has obvious disadvantages. By this method we seem to be deliberately over-dosing patients, with very dangerous drugs; and although it might be justifiable to use it in certain hopeless cases of extensive cancer, it should not be the method of choice in ordinary cases. In a series of 92 cases, Ries reports three deaths.[2]

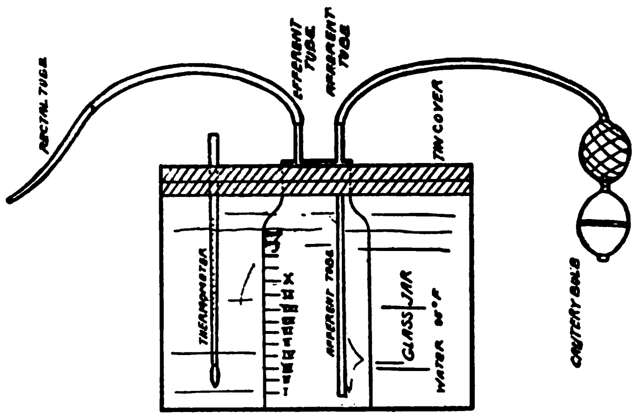
RECTAL ANESTHESIA.

The improved technic and good results of Cunningham of Boston, and Brewer of New York show this form of anesthesia to be safer than at first was supposed. In

1. Available anesthesia is the working anesthesia that ensues after the inhalation is stopped.
2. Ann. Surg., 1905, xliii, 193.

carefully prepared patients and with a gradual administration through a suitable apparatus, very good results can be obtained, and it is, of course, an ideal form of anesthesia for all head and neck operations. The earlier experimenters worked, often, on unprepared patients, and with faulty technic, often having their ether too much heated. As a result collapse and bloody diarrhea sometimes followed. Brewer's series of over one hundred cases and Cunningham's of over two hundred without deaths warrant a careful and intelligent use of the method.

Success depends on a careful preparation. The patient's rectum is emptied by full doses of magnesium sulphate followed by two cleansing enemata, the last one to be given an hour before the operation.



Cunningham's Apparatus for Rectal Anesthesia.

Cunningham's latest apparatus consists of a wash bottle, 7½ inches high and 4 inches in diameter, placed in a large glass jar full of water at 98 F. Five inches of the height of the bottle is occupied by ether, leaving 2½ inches for vapor space. An afferent tube leads to the bottom of the ether; an efferent tube is cut off flush with the stopper in the bottle. A double cautery bulb forces air by the afferent tube through the ether, which it leaves in the form of vapor through the efferent tube.

The efferent tube ends in an ordinary rectal tube. Heat is retained in the glass jar by a tin cover, having a hole for the neck of the bottle, and another for a thermometer which registers the temperature of the water.

With the patient in the dorsal position, one thigh is held slightly elevated by a sandbag, and the rectal tube is introduced eight or ten inches. Gentle pressure of the cautery bulb slightly distends the rectum, and the forefinger, being held at first along the rectal tube, allows the escape of flatus from the rectum. The bulb must now be pressed gently at regular intervals, and as the patient becomes accustomed to the tube the finger may be withdrawn. As the bowel absorbs the vapor, the patient may complain of a desire to defecate, and of slight abdominal discomfort. This is due to distention, and must be met by reintroducing the finger to allow the escape of superfluous vapor.

In from three to five minutes the odor of ether may be perceived in the patient's breath. In two or three minutes more he becomes drowsy, the eyes close, the breathing becomes tranquil, regular, and slightly sterterous, and he passes into complete anesthesia, usually without excitement or struggling. The time necessary to produce complete anesthesia by this means varies from six to fifteen minutes, according to the patient and the absorbing qualities of his rectal mucous membrane. Anesthesia once established is easily maintained by gentle pressures of the bulb every one or two minutes.

After the operation the rectal tube is disconnected from the apparatus, but is left in the rectum, while gentle massage along the course of the colon expels any remaining ether vapor. The rectum is then again cleansed by an enema.

Crile's procedure of packing and intubing the pharynx is a very useful method for producing anesthesia in cases of extirpation of the tongue, resection of the lower jaw, etc. Full anesthesia having been obtained by

the usual methods, two rubber tubes, eight inches long, beveled at the distant ends, are passed through the nares down to the epiglottis. The whole larynx is then firmly packed with a large piece of gauze, and respiration is caried on entirely through the tubes. The upper ends of the tubes are connected with the two arms of a Y-tube. The stem of the Y-tube terminates in a funnel lightly packed with gauze, on which ether is dropped.

This method works very well and absolutely prevents the swallowing or inhalation of blood, mucus and saliva.

The above five procedures are the most important special methods at our disposal for anesthetizing in head and neck operations. A brief mention of certain other operations brings out additional points of interest.

OPERATIONS ON THE BRAIN.

The subjects of these operations are apt to be either restless and delirious, or stupid and lethargic. The former class requires the use of morphin and atropin in small doses; the latter requires no morphin or atropin. When once carefully anesthetized, most brain cases can be controlled with very little of the anesthetic, usually but a few drops of ether or chloroform from time to time. The pulse is frequently slow, and it is easy to over-anesthetize such patients with the production of a serious circulatory and respiratory depression. Therefore a light anesthesia should be maintained.

The method of continuous cardiac auscultation is employed for these cases in Harvey Cushing's clinic. By this means the anesthetist maintains a surprisingly close acquaintance with his patient's condition from moment to moment.

Gas should not be used owing to the sudden rise in arterial pressure that it produces. As a rule, inhalation-anesthesia induced by chloroform or the A. C. E. mixture and maintained by ether (semi-open method), is the best form of anesthesia for brain operations.

For most *rhinologic and laryngologic operations,* such as removal of tonsils and adenoids and nasal spurs, we use ordinary inhalation anesthesia by gas or ether. or by simple ether with the semi-open or closed method. In operations on the frontal sinus, antrum of Highmore, and larynx, special methods are required. Speaking generally, rectal anesthesia answers admirably for all three of the above mentioned operations.

Anesthetization for operations on the larynx may present a very interesting problem, the solution of which is, of course, at hand if rectal anesthesia is used. If it is not used, anesthesia may be induced by the inhalation of chloroform, or A. C. E. mixture, and may be maintained by the same drugs administered through a tracheotomy tube and catheter, at one end of which is a funnel lightly packed with gauze.

The Trendelenburg position and the Trendelenburg tube[3] are useful. This method is disagreeable, however, and not without danger. Rectal anesthesia is preferable.

EMPYEMA.

In operations for empyema the serious mistake is often made of having the patient lie on his side with the sound lung underneath. This hampers respiration. If the patient happens to have abscess of the lung and not empyema, the pus from the abscess cavity may, if the position of the patient is faulty, as described, flow over into the sound lung and suffocate the patient. Commencing the operation with chloroform or C. E. obviates coughing and the production of mucus; the patient may then be charged up with ether and operated on in a sitting position, thus giving the sound lung a good chance to work.

In empyema, rectal anesthesia, if possible, is the ideal form of anesthesia.

Edebohl's operation for decapsulating the kidneys

3. This is an ordinary tracheotomy tube fitted with an inflatable tube to protect the lungs from blood, mucus, etc.

is often done under gas and oxygen administered by Hewitt's apparatus, which provides for varying percentages of oxygen to be given with nitrous oxid. This is undoubtedly the lest irritating form of anesthesia for both kidneys and lungs. A curious fact in connection with it, however, is that temporary glycosuria often follows its use.

For old and middle-aged men, requiring prostatectomy, we find that mixtures of ether and chloroform, preceded by morphin and atropin, make the best form of anesthesia, controlling the patients well, and leaving slight after-effects, provided we do not use spinal analgesia.

An anesthesia produced as described above may often be successfully maintined by using Greene's modification of Fillebrown's thermo-ether inhaler.[4] In this apparatus a foot-bellows forces air by an afferent tube through ether contained in a bottle which is held in a boiler full of water at 98 F. The heat produces a more rapid vaporization of the ether, and thus intensifies its strength. An efferent tube conducts the warm vapor to the patient's mouth, where a patent stop-cock so controls the supply of ether that it is admitted during inspiration only.

The patient must be deeply etherized at first by ordinary methods, otherwise reflex coughing and partial recovery from anesthesia may result when one uses this apparatus.

SCOPOLAMIN-MORPHIN ANESTHESIA.

Scopolamin-morphin anesthesia may be employed in certain cases. The method consists in giving 1 mg. of scopolamin, and 25 mg. of morphin, divided into three equal doses, which are administered two and one-half, one and one-half and one-half hour before the operation, which is to begin one-half hour after the last dose.

4. Am. Pract. Surg., iv, 186.

THE BLOOD CHANGES INCIDENT TO SURGICAL ANESTHESIA, WITH SPECIAL REFERENCE TO THOSE INDUCED BY NITROUS OXID.*

A CLINICAL AND EXPERIMENTAL STUDY.

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The phenomena of general anesthesia had scarcely been appreciated before the corollary arose: Does narcosis harm the animal economy, and, if so, in what particulars? A number of physiologic and clinical studies have been made by different investigators to determine whether the anesthetics ordinarily employed are harmful. The present study may be grouped with these researches and was undertaken at the suggestion of Dr. A. D. Bevan with the hope of defining as accurately as possible the blood changes incident to nitrous oxid anesthesia. The increasing use of this gas as an anesthetic in major surgical operations, as well as the increasing time of anesthesia, were factors which prompted the investigation. In particular, we attempted to answer the following questions: 1. Does nitrous oxid reduce the hemoglobin and thereby cause anemia? 2. Does it cause hemolysis? 3. Does it increase the coagulability of the blood and thereby increase the danger of postoperative thrombosis? 4. Are its effects on hemoglobin, red blood cells, coagulation, etc., more harmful than those produced by chloroform or ether? 5. Are there other untoward blood changes? In a rather careful inquiry into the literature nothing was found bearing specifically on these points.

* From the Surgical Clinic of Dr. A. D. Bevan, Presbyterian Hospital, and the Laboratory of Experimental Therapeutics, S. A. Mathews, director, the University of Chicago.

Hewitt,[1] dealing with anesthetics in general, writes as follows:

Little is accurately known as to the changes which anesthetic gases and vapors produce in the blood itself.

Speaking generally, it would seem that most anesthetics enter and leave the blood without producing in it any destrucive or important changes save those which must inevitably result from interference with normal respiration necessarily incidental to the plan of administering anesthetics by inhalation. When, as is the case with certain of these agents, the oxygen supply is greatly diminished or the elimination of carbonic acid is retarded, the usual effects of asphyxial blood on the medullary centers and cardiovascular system will be produced. Sansom, Wittich, Böttcher and other observers, however, have described alterations in the red blood corpuscles, and according to the Glasgow Committee of the British Medical Association, disintegration of these corpuscles takes place within the pulmonary capillaries during inhalation. Grube urges that as urobilinuria may occur two or three days after anesthesia, it is probable that the destruction of red blood corpuscles is a result rather than an accompaniment of the administration.

METHODS.

The observations about to be reported are based on clinical and experimental work. The clinical observations were made on patients in the various surgical services of the Presbyterian Hospital. The experimental work was done in the Laboratory of Experimental Therapeutics at the University of Chicago, dogs being used for the purpose.

The clinical data were obtained in as nearly a routine manner as possible. The blood readings were taken in the morning at about the same hour and usually just before the beginning of the anesthesia. The hemoglobin was read with the Dare instrument, the mean of three readings being taken. The red and white cells were counted in the usual way with the Thoma-Zeiss apparatus. The volume index was obtained after the manner

1. Anesthetics and Their Administration, London, 1907, pp. 66 and 99.

advised by Capps[2] by the use of dry clean hematocrit tubes on the electric centrifuge. The coagulation time was determined by the Brodie and Russell coagulometer, as modified by Boggs.[3] Some of the earlier readings were taken by the Hayem method, but these tallied so closely with the others that they are included as well.

Whenever possible, the second readings were taken in the cases of gas anesthesia while the patients were narcotized and while moderately cyanotic. The third reading was made immediately after the inhaler had been removed, but not until the patient was awake, perfectly conscious and showing no trace of cyanosis. The readings were obtained for the fourth time twenty-four hours later, and in some cases again seventy-two and ninety-six hours, and again in from five to seven days. The omissions in the tables are due to unavoidable happenings, such as immediate departure of patients after short anesthesia, the interference of some more necessary duty at the exact reading time, the death of patients, etc.

No attempt was made to select cases, but for the most part no severe hemorrhage or other factor arose which might have influenced the readings. One case of chronic obstructive jaundice was excluded because of the uncertainty of color estimation in the presence of bile pigment. In all, twenty cases were examined to determine the effect of nitrous oxid anesthesia on hemoglobin alone, eight cases in which the reds were counted along with the hemoglobin readings and the color index determined, fifteen cases to determine the effect of nitrous oxid on coagulation time, twenty-five cases as a control, showing the effects of ether; in addition a few red cell volumetric determinations, urinary examinations for urobilin, gross leucocyte counts and differential preparations for nucleated reds were made.

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2. Jour. Med. Research, 1903, 10. 367.
3. Hinman and Sladen: Bull. Johns Hopkins Hosp., 1907, xviii, 207.

The experimental work was done on forty-two dogs. The hemoglobin, red count, volume index and coagulation time were determined before, during and after anesthesia with nitrous oxid, ether and chloroform, respectively. The nitrous oxid series was amplified by specific gravity readings (method of Hammerschlag) and spectroscopic determinations. Likewise a number of experiments were performed to determine the physiologic mechanism responsible for the blood changes.

One of us (Ewing) investigated further the effects of anesthesia on the fixed tissue cells, as well as the relation of increased coagulability and peritoneal irritation to postoperative thrombosis. These results will be published subsequently in a separate communication.

EFFECT OF ANESTHESIA ON HEMOGLOBIN AND ERYTHROCYTES.

NITROUS OXID ANESTHESIA.

(*a*) *Literature.*—The first noteworthy contribution on blood changes due to anesthetics appeared in a report to the Royal Medico-Chirurgical Society in 1861, wherein Sansom[4] showed that anesthetic substances added to blood in test-tubes destroyed its corpuscles and liberated hemoglobin. A few years later, in 1869, McQuillen.[5] after an examination of patients' blood before and after anesthesia with ether, chloroform and nitrous oxid, stated there was no evidence of corpuscular degeneration. Amory,[6] in 1870, experimenting on dogs, came to the conclusion that nitrous oxid anesthesia diminishes the amount of carbon dioxid exhaled by almost one-half.

Turnbull,[7] experimenting on frogs and rabbits, in 1879, found no perceptible change in the morphology of the red corpuscles after the animals had been placed in containers of nitrous oxid and allowed to remain there

4. Quoted by DaCosta and Kalteyer: Am. Surg., 1901, 34-329.
5. Dent. Cosmos, March, 1869.
6. N. Y. Med. Jour., xii, 1.
7. Quoted in Lyman: Artificial Anesthesia and Anesthetics, New York, 1881.

until stupefied. MacMunn,[8] in 1880, stated that in the arterial blood of an animal killed with nitrous oxid are only spectrum lines of reduced hemoglobin, while that of an animal dead from chloroform gave an oxyhemoglobin line very clearly. Ulbrich,[9] in 1887, found no hemoglobin by spectroscopic analysis in blood saturated with nitrogen monoxid. Rothman,[10] working a year later with more dilute solutions of such blood, established the spectrum of hemoglobin unimpaired. The results of Rothman agree with those of Hermann,[11] Jolyet and Blanche,[12] Golstein,[13] McMunn,[14] Buxton and Halliburton.[15]

Van Arsdale[16] concludes there is no true combination of nitrous oxid with hemoglobin; that the spectrum lines are unchanged; that the nitrogen monoxid goes into solution in the plasma, and that there is a real specific anesthetic action.

Kemp[17] experimented on fifty dogs to determine whether or not anesthesia was due to asphyxia or to some specific action. In an analysis of the blood gases during nitrous oxid anesthesia, he finds complete anesthesia possible while the blood is carrying about 8.5 per cent. of O, 25 per cent. of N_2O, and 17 per cent. of CO_2. He found, further, that the blood mixed with soda solution in the canula connecting the animal with the kymograph, always gave the spectrum of oxyhemoglobin, and that attempts at producing a compound of nitrous oxid and hemoglobin by saturating the blood with the gas always resulted negatively. He reasons that the gas is held in simple solution in the plasma in an amount equal to that absorbed by water, and concludes that nitrous

8. The Spectroscope in Medicine, London, 1880, xiii, 73.
9. Prag. med. Wchnschr., 1887, (22).
10. Vierteljähr. f. Zahnheilk., 1888, No. 3.
11. Arch. f. Physiol., 1864, 524-526.
12. Arch. f. d. ges. Med., 1878, 334-336.
13. Id.: 1878, xvii, 135.
14. Dublin Jour. Med. Sc., 1879, p. 210-211.
15. Trans. Odont. Soc. Gt. Brit., 1887, xix, 96.
16. Am. Jour. Med. Sc., 1891, 102, 131.
17. Brit. Med. Jour., 1897, 2, 1480.

oxid is a specific anesthetic not dependent on asphyxia for its effects.

(*b*). *Clinical Results.*—The twenty cases (Table 1) in which the effect of nitrous oxid anesthesia on hemoglobin was studied and on which the following deductions are based, consist of anesthesias of varying lengths, from three to thirty minutes, with an average of 16.1 minutes. The time noted is the actual time the patient was supposed to be narcotized. The hemoglobin range before anesthesia was from 59 to 98 per cent., with an average of 78.4 per cent. The hemoglobin readings (Dare) during anesthesia varied from 75 to 120 per cent., with an average of 88 per cent. The readings immediately after the patient became conscious ran from 60 to 87 per cent., with an average of 74 per cent. Those taken twenty-four hours later varied from 58 to 100 per cent., with an average of 76.9 per cent.

In a summary of four cases in which the readings were taken without a break in the series, the averages before, during, and immediately after, and in twenty-four hours, were 75, 89.1, 70.5 and 74.2 per cent. In a series of seven cases, which is complete, with the exception of the late twenty-four-hour reading, the averages are 83.4, 90.4 and 70 per cent. for the same readings as above.

In a total estimation of the average rise, fall, immediately afterward and of the fall in twenty-four hours, we find 10.3, 5.2 and 1.3 per cent., which, expressed in percentages of the average hemoglobin reading before, is 13, 6.5 and 1.6 per cent.

We may say, then, that during nitrous oxid anesthesia there is an increase of 13 per cent. in the Dare reading of hemoglobin while the patient is narcotized and showing a shade of cyanosis; that there is a fall of 6.5 per cent. immediately the mask be removed, and that this fall is reduced to 1.6 per cent twenty-four hours later, apparently showing that it was a transient phenomenon.

What this rise and fall is due to, whether or not there is a true polycythemia in the first instance and an

oligocythemia in the second were the immediate problems which presented themselves, once the stability of the curve had been established. To this end, eight cases were investigated and the reds counted, together with Dare readings, and the color indices determined.

(*c*) *Effect on Hemoglobin, Red Blood Cells and Color Index in a Series of Eight Clinical Cases.*—The results of these have been grouped together in Table 2. Because of incomplete records, the readings during anesthesia have been omitted. In three cases in which the hemoglobin was read during anesthesia, however, the same increase shown in Table 1, from 10 to 17 per cent., was noted. The red count in one of these cases increased 900,000 cells during narcosis. We have averaged the readings similarly to the hemoglobin readings in the preceding table and find the following:

The hemoglobin readings before, immediately after, twenty-four to forty-eight hours later, and five to seven days after, are 74.3, 72.4, 76.6 and 81.3 per cent., respectively. Analyzing these briefly, we see a slight fall immediately after the anesthetic, as in Table 1. The reading twenty-four hours later, however, is slightly higher than the original (2.3 per cent.), while the late hemoglobin reading shows a 7 per cent. increase.

The red count, on the other hand, does not follow this hemoglobin change accurately. Instead of the fall immediately after consciousness is regained, there is a slight increase in the number of circulating reds, an apparent polycythemia of 177,000 cells. This rises still higher twenty-four hours later when an increase of 333,-700 cells is noted. By the fifth to the tenth day, however, the count has very nearly reached normal, although a slight increase above the original average still persists.

Calculating the color index (relative percentage of contained hemoglobin) from the above values we find a slight drop of 0.06 per cent. immediately after anesthesia; a gradual return to almost normal (throughout this paper "normal" blood readings are to be interpreted

as the readings of that particular case before the anesthetic was administered) in twenty-four hours, and a steady increased absorption of hemoglobin coloring matter until on the seventh day the index is 0.04 per cent. above the original quotient.

Briefly, we may summarize these findings by saying that in this series of clinical cases nitrous oxid produced little change in the relation of the blood cells to their hemoglobin content; that the fall of hemoglobin noted immediately after anesthesia was not followed closely by a corresponding fall in the red count, but that, if anything, there was a slight increase in the number of the circulating reds which persisted, and that, as an end result, there was a slight increase in the hemoglobin content per cell and no demonstrable change in the number of the red blood corpuscles.

These facts would show that there was no grave result from the anesthesia so far as hemoglobin estimates and red cell enumeration could determine. The immediate hemoglobin fall was still unexplained and appeared constant. The other variations were slight and not constant, and appeared to be within the bounds of experimental error.

As a result of these two investigations, there appears to be no oligocythemia due to hemolysis and no persisting oligochromemia or anemia. But the problem of the great increase in the Dare reading during anesthesia, the question whether this is due to a true polycythemia, anhydremia or other phenomenon was still unsettled. For the solution of this question we turned to the laboratory and began our experimental work on dogs.

(*d*) *Changes in Hemoglobin, Erythrocytes, Color and Volume Indices, Specific Gravity and Leucocytes in a Series of Experimental Animals.*—The results in these experiments were obtained from a series of readings on seven full grown healthy fox terriers, ranging from 4 to 7 kilos in weight. The blood was obtained from a vein, exposed after washing and shaving the inner sur-

face of the ear. We found this to be important, that the blood might be obtained running freely from the cut vein, as even the slightest pressure caused a wide variation in the readings. There was no further preparatory treatment, such as limitation of the diet and water, or the administration of any drug. Immediately after anesthesia the dogs were placed in separate cages until conscious, and were then allowed their usual diet with no restrictions.

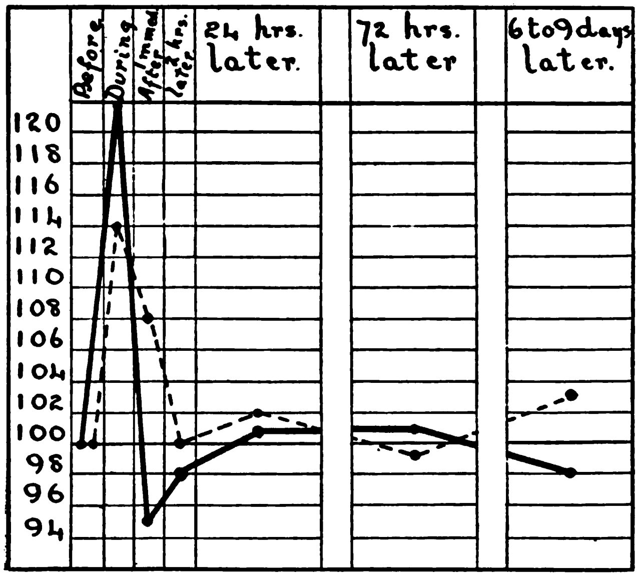

Fig. 1.—Curve showing effect of nitrous oxid anesthesia on hemoglobin (solid line) and erythrocytes (broken line). Summary of results of seven animal experiments (Table 4).

The protocols of the several experiments have been grouped as compactly as may be in Table 3 in the order of lengthening time of anesthesia. In order that the readings may be more easily interpreted and connotated, we have prepared Table 4 which shows the average readings of the seven cases for each component separately (Chart 1). An inspection of these results brings forth some very striking facts.

In the first place, we see the same rise and fall in the Dare hemoglobin readings as noted clinically in Tables 1 and 2. We see further that this apparent fall comes nearly back to normal in two hours after anesthesia; that twenty-four hours later it is not only back but slightly higher than the original and that this gradually falls till on the sixth to the ninth day it is practically what it was before anesthesia began.

A study of the erythrocytes shows a most interesting phenomenon, namely, that during anesthesia there is an apparent large increase in the number of red cells, 874,000, and still more suggestive, that as soon as the dog is conscious this high red count has already started to fall, and two hours later has reached a point equal to that before the experiment was started. The subsequent red counts for the succeeding days hover around this same count and show no constant change.

That the change in hemoglobin and reds does not go absolutely hand in hand, is well brought out by the color index readings wherein we see a high decimal during anesthesia, followed by a low reading immediately after. In two hours, however, the quotient is the same as the first reading and remains so with slight oscillations till the ninth day.

The volume index readings were desired in the first instance to control any change in the integrity of cell volume due to nitrous oxid anesthesia, and secondarily to investigate from no particular *a priori* consideration any volumetric change which might occur. The hematocrit readings show clearly that the gross volume of cells follows closely the increased cell count, thereby ruling out any variation in the percentage volume of the individual corpuscle.

The specific gravity readings show a rise during and immediately after anesthesia, with a return to the normal in two hours. This agrees closely with the expected change due to the increased blood weight from the concentration of cells.

Leucocyte counts were taken merely for the sake of completeness and to see if they corresponded to the red cell readings. An inspection shows a curve following closely that of the erythrocytes, with the single exception in the two-hour reading which, instead of dropping to the normal, as the majority of the other components do, remains high, to gradually reach normal in twenty-four to seventy-two hours.

The anesthesias in this series were all performed in the same manner, with the exception of Cases 3 and 4, in which a mixture of from 3 to 4.5 per cent. of oxygen was substituted for air. It was thought interesting to see if there was any demonstrable change in the various readings due to the interpolation of oxygen gas because of the fact that at present many nitrous oxid anesthesias are being given with this admixture.

Table 5 shows a summary of the two nitrous oxid-oxygen cases with the five nitrous oxid-air series. Analysis shows a very interesting difference insofar that the hemoglobin readings in the oxygen cases show practically no greater change than the increased cell count would demand; the color index thereby not showing the increase noted in the nitrous oxid-air cases. The explanation of this difference we hope to demonstrate later in the paper.

The growing tendency of clinicians to use nitrous oxid in cases requiring long anesthesia lead us to investigate the variations in blood changes dependent on increased time and therefore, amount of nitrous oxid employed. Table 6 shows a comparison of two cases of over two hours' duration with two cases of less than forty-five minutes' duration. A survey of these cases shows that a greater rise of red cells, hemoglobin and specific gravity occurs during prolonged anesthesia; that the color index remains unchanged and that in two hours this increase in reading drops to normal. Summarizing the facts this series has established, we find that:

1. The rise and fall in hemoglobin readings first observed clinically holds true in experimental animals. 2. The return to normal occurs within two hours after anesthesia. 3. There is an accompanying rise and fall of erythrocytes. 4. This change does not exactly correspond to the hemoglobin change as shown by the high blood decimal during anesthesia and the low quotient immediately after. 5. The percentage volume undergoes little if any change. 6. The specific gravity increases and decreases hand in hand with the red cell change. 7. There is a postnarcotic leucocytosis closely following the red cell curve.

The physiology of these various phenomena and their significance we have grouped under a separate heading, for the explanation of which we must include a number of isolated experiments.

(*e*) *Physiology of Blood Changes Under Nitrous Oxid Anesthesia.*—We first attempted to explain experimentally the hemoglobin rise during nitrous oxid anesthesia. Thinking that the Dare readings might be erroneous because of lack of oxygenation, we compared them with a series of von Fleischl readings of the same blood inasmuch as the blood during the latter manipulation undergoes thorough mixture with water and air. Table 8 shows the results of such a comparison with controlling red cell counts and color index determinations. This shows a marked discrepancy of an average of 10 per cent. in the hemoglobin readings as read with the two instruments. Also we see that the color index with the Dare increases, while the von Fleischl remains unchanged. These results lead us to the conclusion that the hemoglobin as read by the von Fleischl instrument is the most correct insofar as the hemoglobin is thoroughly exposed to the air by the process of dilution, and as it follows exactly the changes in the red counts.

Why does the Dare instrument read high during nitrous oxid anesthesia? It was a striking fact noted

early in the investigation that the blood was not only blue as it streamed out over the patient's ear, but remained blue in the Dare holder. To elucidate this problem we did the following things: Ten cubic centimeters of blood were withdrawn from the carotid artery of a dog after he had been partially anesthetized with ether. This was defibrinated and a number of Dare determinations and spectroscopic examinations were made. Nitrous oxid was then passed through for ten minutes. At the end of this time there was no gross change in the color of the blood; a second group of Dare readings showed the same average; the spectroscope showed unchanged oxyhemoglobin.

These negative findings suggested the theorem: Inasmuch as nitrous oxid alone in the test-tube produces no change comparable to the change found in anesthetized animals' blood, what is the causative factor? To this end blood was withdrawn from the carotid artery of three dogs during anesthesia, defibrinated, and the Dare reading taken. Pure oxygen gas was then passed through for five minutes and the hemoglobin again read. Table 8 shows the results of these readings, showing a drop of 24.8 per cent., from 114.8 before to 90 per cent. after gas had been passed through.

We concluded, then, that inasmuch as there was no demonstrable change from nitrous oxid and blood alone in the test tubes, and because the blood under nitrous oxid anesthesia can be brought back to what it was before anesthesia (by passing oxygen through it in a test tube) that part at least of the high hemoglobin reading was due to some product contained in the cyanotic, anesthetized blood and removable by a stream of oxygen.

What is this product? All previous authors (except Ulbrich) were unable to demonstrate any change in the spectroscopic readings. Our first spectroscopic determination on the blood of five dogs during anesthesia, taken in the usual way by mixing a few drops of blood

with salt solution in a chamber, showed nothing but lines of oxyhemoglobin. Our second set of experiments, however, on three dogs deeply anesthetized, showed lines of reduced hemoglobin. This was accomplished by preventing the oxidation of the hemoglobin by collecting the blood under oil, with a canula immersed in salt solution. By very high dilution the lines of oxyhemoglobin were obtained. These results show very clearly that the product which causes the high Dare reading is reduced hemoglobin.

We find further that this reduction in hemoglobin is not due to the anesthesia *per se,* but to the acompanying asphyxia—note the differences in the hemoglobin reading under the nitrous oxid-oxygen mixture as contrasted with the nitrous oxid-air mixture (Table 5)—as well as the disappearance of the blue reduced hemoglobin under a stream of oxygen and the inability to produce same with nitrous oxid alone.

The explanation of the high red count under gas is still an open question, except from the standpoint of the possible explanation of a local capillary stasis. The drop in hemoglobin to normal as soon as the mask is removed is made clear on the basis of the removal of the high-reading reduced hemoglobin by oxygenation. The drop continuing to below normal remains unexplained. That this is of little consequence is strikingly shown by the fact that in two hours all the readings are equivalent to those before anesthesia. Were they of moment they would not come back so quickly.

We investigated further the question of hemolysis and increased red cell regeneration by a series of smears before and after anesthesia, looking especially for nucleated reds; by examination of the urine for urobilin; by an examination of the plasma in the hematocrit tube for blood coloring matter; all of these examinations resulted negatively; no definite evidences of hemoglobin or increased hematopoietic activity could be found.

Finally, therefore, we conclude that nitrous oxid anesthesia does not reduce hemoglobin and thereby cause anemia; that it does not cause increased hemolysis; that what apparent change it does produce on hemoglobin and red cells is transient and of no clinical significance.

CHANGES DUE TO ETHER ANESTHESIA.

(*a*) *Literature.*—The first specific examination for blood changes due to ether anesthesia appeared in 1895 (although Bierfreund,[18] reporting from Mikulicz's clinic in 1890, found a hemoglobin destruction of from 5 to 10 per cent.) when DaCosta examined the blood of twenty-seven operative cases, before, during and after etherization.[19] He concluded that etherization produces a marked diminution in the hemoglobin of the blood and caused an alteration in the morphology of the red blood corpuscles with no decrease in their numbers. Further, that blood previously diseased—in anemic individuals—is especially susceptible.

Buxton,[20] in 1896, found destruction of corpuscles and liberation of hemoglobin when shaking blood with ether, and thinks that a similar, although less marked phenomenon occurs in the body. Oliver,[21] the same year, saw the necessity of controlling the above observations on animals and from observations on rabbits anesthetized for an hour with ether found no changes in normal red corpuscles, but admits it may affect those already diseased.

The following year von Lerber[22] reported a study of the blood in 101 cases after the inhalation of ether. He found that in most cases the hemoglobin was unaltered; that the red blood corpuscles were morphologically and numerically unchanged, and that spectroscopic urinary

18. Langenbeck's Arch., 1890-91, xli, 1.
19. Med. News, March 2, 1895.
20. Lancet, Feb. 1, 1896.
21. Lancet, June 27, 1896.
22. Centralbl. f. Gyn., 1897, 19.

examination for urobilin was negative, concluding that there was no hemolysis and liberation of hemoglobin.

In 1889 Hamilton Fish,[23] theorizing from examination of patients' blood before and during anesthesia, states that ether reduced hemoglobin and exerted a harmful effect on red blood corpuscles.

In 1901, from an exhaustive study of the literature and 50 operative cases, DaCosta and Kalteyer[24] concluded as follows: "The number of red corpuscles is influenced by many factors accompanying the anesthetic state. The character of this change is, as a rule, a polycythemia—rarely an oligocythemia. The nature of this polycythemia seems best explained by a lessening of the watery elements of the plasma. It seems reasonable to infer that the polycythemia is not influenced by excessive proliferative changes which probably occur in the hematopoietic tissues. The three important factors incident to polycythemia are, (a) the period of preparatory operative treatment, viz., hot bath, active purgation, etc.; (b) the anesthetic state—particularly sweating; (c) postoperative stage—particularly vomiting. The blood inspissation is, as a rule, most pronounced immediately after the termination of the anesthetic stage. The hemoglobin is always reduced absolutely. We conclude that etherization produces increased hemolysis and in Nature's effort to rapidly replace the degenerated corpuscles, the regenerated cells are imperfectly supplied with hemoglobin."

Anders and Boston,[25] in 1904, confirmed the fact that ether produces increased hemolysis, but find that it is followed by rapid regeneration of cells, with an increase in the number of red corpuscles. Dawson,[26] in 1905, came to the same conclusions.

(*b*) *Changes in Hemoglobin, Erythrocytes, Color and Volume Indices in a Series of Experimental Animals*

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23. Ann. Surg., July, 1899.
24. Ann. Surg., 1901, 34, 329.
25. Lancet, June 1, 1904.
26. Edin. Med. Jour., November, 1906, 26.

Under Ether Anesthesia.—Ether was administered to five dogs on different days, the time of anesthesia varying from fifteen minutes to two hours and twenty-eight minutes. Table 9 shows the readings of the various blood components. The last group of figures is an average of the five sets above (Chart 2).

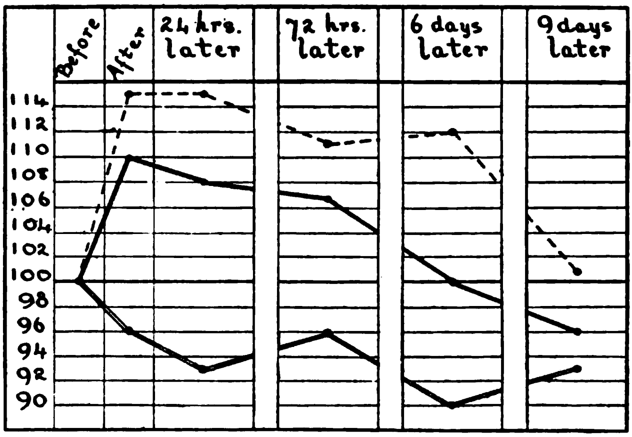

Fig. 2.—Curve showing effect of ether anesthesia on hemoglobin (solid line) and erythrocytes (broken line). Color index indicated by double line. Summary of results of five animal experiments (Table 9).

The hemoglobin reading taken during anesthesia shows an increase which remains high until the fifth to the seventh day, and on the eighth to the tenth day shows a slight drop of 3 per cent. This is in marked contrast to the N_2O readings where the hemoglobin dropped immediately and came back to normal in twenty-four hours.

The red count shows a rise immediately after anesthesia which persisted high until a gradual decline to normal on the eighth to the tenth day. This, again, is in contrast to the N_2O count where the apparent polycythemia disapeared in two hours.

The color index shows a rather constant drop, starting immediately after anesthesia and reaching its lowest point on the fifth to the seventh day. This would indicate a relative loss of hemoglobin per cell, and again is

unlike nitrous oxid results, where the only sign of a low color index is found immediately after the anesthetic mask is removed, and which is completely gone in two hours.

The volume index likewise shows an immediate loss, which is most marked in twenty-four hours, and again on the fifth to the seventh day. In the nitrous oxid readings the percentage volume remained unchanged throughout.

These results show that ether administered to experimental animals caused: (1) An increase in the hemoglobin persisting until the eighth to tenth day; (2) an increase in the number of erythrocytes persisting with slight remissions until the eighth to tenth day; (3) a loss in the relative amount of hemoglobin, most marked on the fifth to seventh day; (4) a loss in the percentage volume, most marked on the fifth to seventh day.

The apparent polychromemia and polycythemia are well explained by the anhydremia or inspissation mentioned by DaCosta and Kalteyer. The continued abstraction of the watery elements of the plasma would explain the loss in volume of the red cells due to shrinkage, the return to normal volume and normal cell count occurring synchronously. The loss in the relative amount of hemoglobin can only be explained as a true oligochromenia. This agrees with the ideas of Bierfreund,[18] DaCosta and Kalteyer,[19] Buxton,[20] Fish,[23] Anders and Boston[25] and Dawson.[26]

THE CHANGES DUE TO CHLOROFORM ANESTHESIA.

(*a*) *Literature.*—Harley,[27] as early as 1864, investigating the effect of chloroform on the blood, described various degrees of red blood cell disintegration. Guthrie,[28] in 1897, brings forth corroborative evidence and quotes the work of Ostertag, McKendrick, Sansom, Wittich and Bottcher as supporting Harley's findings.

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27. Trans. Roy. Med. Clin. Soc., 1864, p. 159.
28. Clin. Jour., March 24, 1897.

Solimeii,[29] in 1902, found a decrease in hemoglobin and erythrocytes and moderate poikilocytosis after chloroform narcosis. Holman[30] discusses danger of chloroform hemolysis in anemic blood. Dawson,[31] in 1905, however, takes a view opposite from the above and quotes several observations to the point that chloroform produces only slight hemolysis and does not materially reduce hemoglobin.

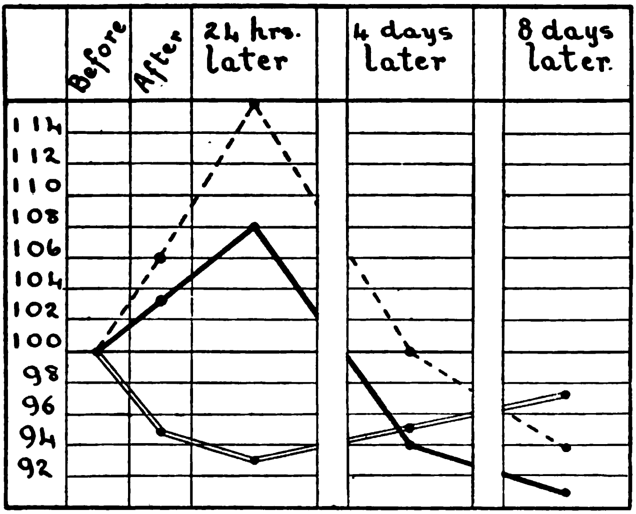

Fig. 3.—Curve showing effect of chloroform anesthesia on hemoglobin (solid line) and erythrocytes (broken line). Color index indicated by the double line. Summary of five animal experiments (Table 10).

(*b*) *Changes in Hemoglobin, Erythrocytes, Color and Volume Indices in a Series of Experimental Animals Under Chloroform Anesthesia.*—We investigated the effect of chloroformization on five dogs varying from eighteen minutes to two hours and forty-five minutes (Table 12, Chart 3). The hemoglobin per cent. shows a rather unusual change in the high reading on the day after anesthesia. The most significant fact, however, is the late fall in hemoglobin to 8.4 per cent. less than the

29. Gazz. d. osp. e. d. clin., 1902, xxiii, 108.
30. St. Paul Med. Jour., 1902, ix, 618.
31. Loc. cit.

start. This is in contrast to the 1.1 per cent. fall under nitrous oxid and the 3 per cent. fall under ether.

The red cells show the same unusual rise in the twenty-four hour reading, following the hemoglobin curve. The absolute number is, however, relatively decreased on the seventh to tenth day. This again is to be compared to the slightly increased number found in the late readings of nitrous oxid and ether.

The relative amount of hemoglobin—color index—remains little altered throughout the readings. In general there is a slight reduction throughout, which is most marked in twenty-four hour column. The volume index is also of little interest, showing the greatest reduction in the twenty-four hour reading, when the cell count is the greatest.

We may interpret the above as showing that chloroform administered to experimental animals causes (1) a temporary rise in hemoglobin, followed by a diminution to below the normal, most marked in the seventh to tenth day; (2) a temporary increase in the number of erythrocytes followed by a decrease to below the normal, most marked on the seventh to tenth day; (3) little alteration in the color and volume indices.

The temporary polychromemia and polycythemia are explained by the anhydremia similar to the change from etherization. This has been noted clinically by King.[32] The late oligochromemia and oligocythemia are significant, however, and must be interpreted as due to blood destruction, agreeing with the observations previously quoted, excepting those of Dawson.

CHANGES PRODUCED IN THE COAGULATION TIME OF THE BLOOD BY NITROUS OXID, ETHER AND CHLOROFORM ANESTHESIA.

The study of the coagulation time of the blood in relation to general anesthesia was undertaken because of the possible light it might throw on the question of post-

32. Am. Jour. Med. Sc., 1902, 124, 450.

operative thrombosis after clean surgical operations. It was made both clinically and experimentally. The experimental work on dogs was done so that all other factors, except the anesthetic—such as loss of blood, traumatism, etc.—might be eliminated. The clinical study was made on fifteen patients anesthetized with nitrous oxid and twenty-five with ether. The experimental work was done on five dogs anesthetized with nitrous oxid, five with chloroform, and fifteen with ether. The discussion will be divided into two parts, clinical and experimental.

Effect of Nitrous Oxid Anesthesia.—This study was made on fifteen cases from Dr. Bevan's surgical clinic (Table 11). The coagulation time was taken before anesthesia, twenty-four hours after, and on the third, sixth, seventh and tenth to fourteenth days after anesthesia. Care was taken to select cases in which there was no known factor present which would change the coagulation time. Case 8 is an exception to this, however, for on the third, fourth and fifth days after operation, he was given 60 grains of calcium chlorid daily per rectum.

A study of Table 11 shows that the average time of anesthesia was 24.8 minutes. Of the fifteen cases, 9 (60 per cent.) showed a rise in the coagulation time of the blood, 4 (26⅔ per cent.) showed practically no change, while 2 (13½ per cent.) showed a fall in the coagulation time. One of these two was the case in which calcium chlorid was given. The average of the fifteen cases shows the coagulation time before anesthesia to be 6.36 minutes. This rises and on the third day after anesthesia is highest, being 7.19 minutes or an increase of 13 per cent. By the sixth to seventh day this has fallen to 6.76, and by the tenth to fourteenth day to 6.69, which is slightly above what it was before anesthesia. It appears from these cases that nitrous oxid anesthesia does not cause a constant change in the coagulation time, but that in general it causes a rise, which is

not great (13 per cent.) and which is most marked about the third day, coming back to approximately normal by the tenth day.

Effect of Ether Anesthesia.—Twenty-five cases were included in this series. Coagulation time was taken as in the previous series and results are shown in Table 12. The average duration of anesthesia was 54.9 minutes. Of the twenty-five cases, twenty-three showed a decrease in the coagulation time, while only two showed an increase, and that only slight. The average coagulation time before anesthesia was 7.04 minutes. This falls slightly up to the third day after anesthesia, and then falls rapidly until by the seventh to tenth day it is only 4.16 minutes—a fall of slightly over 40 per cent. By the eleventh to eighteenth day it has risen to 6.1 minutes, but is not quite back to normal. From this series it appears that ether causes a marked reduction in the coagulation time, which is greatest seven to ten days after anesthesia.

When these results are compared to those obtained after nitrous oxid anesthesia a marked difference is seen. In nitrous oxid anesthesia the change was not constant and consisted, in general, of a slight rise, while in ether an almost constant drop in the coagulation time occurs, which is very marked, being on an average about 40 per cent.

EFFECT OF NITROUS OXID ETHER AND CHLOROFORM ANESTHESIA ON THE COAGULATION TIME AS SHOWN BY ANIMAL EXPERIMENTS.

In these experiments five healthy dogs were used in each series. In addition to the five dogs which were given the anesthetic alone, ten more were included in the ether series, five of which had the peritoneum opened and packed with wet sponges and five opened and packed with dry sponges. These are included because they show the same changes that occur when only the anesthetic is given.

A study of Table 13 shows that the same result was obtained on dogs who were given nitrous oxid without operation as was obtained on the clinical cases (Table 11). The average coagulation time was increased from 3.45 minutes before anesthesia to 4.8 minutes after anesthesia. One case showed a slight decrease in the coagulation time. These are very similar to the clinical results and confirm them.

In like manner the experiments on dogs with ether showed the same change in the coagulation time that had been observed clinically. The average coagulation time is lowered from 3.96 minutes before anesthesia to 1.88 minutes by the seventh to tenth day—a change of 52 per cent.

In regard to chloroform, no clinical data were obtainable because this anesthetic is seldom used in the Presbyterian Hospital. For this reason only the animal experiments can be included in this report. The results of these experiments are shown in Table 15. Four of the five dogs showed a decrease in the coagulation time, one dog an increase. The average shows a decrease from 4.2 minutes before anesthesia to 3.4 minutes on the seventh to tenth days—a change of 19 per cent. This is seen to be similar to the changes under ether anesthesia, though not so marked (Chart 4).

In general, we may say that the animal experiments confirm the clinical studies, as the results are practically the same. From these clinical findings and animal experiments we conclude therefore that:

(1) The changes produced in the coagulation time by nitrous oxid anesthesia are not constant, but that, in general, it causes an increase which is slight.

(2) That ether anesthesia produces a marked decrease in the coagulation time of the blood.

(3) That chloroform also produces a decrease in the coagulation time, which is, however, not so marked as that produced by ether.

It has not been shown that the change in coagulation time has any relation to thrombosis after operation. This question will be taken up in a subsequent report by one of us (Ewing), but if such relation does exist, as is probable, the presumption is that thrombosis would be less apt to follow gas than ether or chloroform anesthesia.

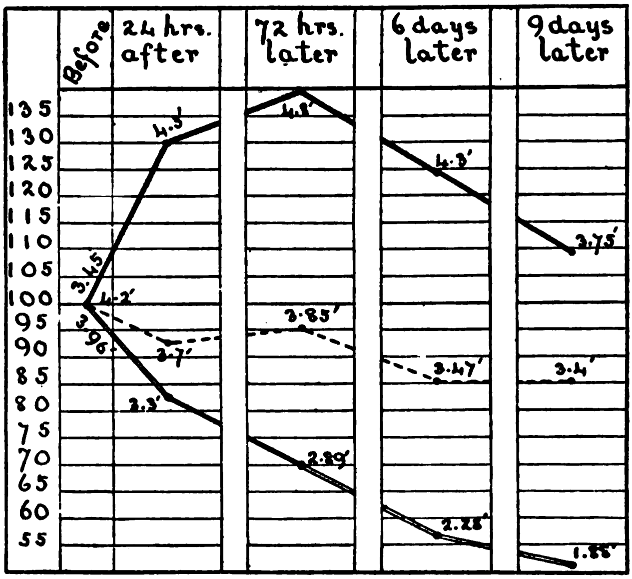

Fig. 4.—Curve showing effect of nitrous oxid (solid line), chloroform (broken line) and ether (double line) anesthesia on the coagulation time of the blood. Summary of results of twenty-five animal experiments (Tables 13, 14 and 15).

SUMMARY AND CONCLUSIONS.

1. In an analysis of the blood changes incident to nitrous oxid anesthesia in a series of clinical and experimental observations we find that:

(a) The hemoglobin is not permanently reduced nor is anemia produced.

(b) Hemolysis is not increased.

(c) The changes in the readings of the hemoglobin and erythrocytes are transient and of no surgical significance, and are most likely to be explained on the

basis of capillary stasis. The production of reduced hemoglobin is not a result of the anesthetic itself, but is due to the accompanying asphyxia.

(d) The changes in coagulation time are not constant, but in general there is an increase in the time required for clotting most marked about the third day.

2. In an analysis of the blood changes incident to ether anesthesia in a series of experimental observations we find that:

(a) The hemoglobin is slightly reduced and therefore a slight anemia is produced.

(b) Hemolysis is not materially increased.

(c) The changes in hemoglobin and erythrocytes are to be explained on the basis of blood inspissation.

(d) It causes a marked decrease in the coagulation time, most marked from the seventh to tenth days.

3. In an analysis of the blood changes incident to chloroform anesthesia in a series of experimental animals, we find that:

(a) The hemoglobin is reduced, and therefore an anemia is produced.

(b) Hemolysis is increased.

(c) It causes a slight decrease in the coagulation time, most marked in the seventh to tenth days.

4. In a comparison of the three anesthetics from the standpoint of the blood changes we conclude that nitrous oxid causes no permanent effects of any significance; that ether causes more harmful changes (slight anemia and marked decrease in coagulation time); that chloroform causes the most harmful results (hemolysis and production of distinct anemia).

We wish here to express our appreciation to Dr. Bevan for his interest and encouragement throughout the progress of this work, and to Dr. S. A. Matthews for his generous aid and assistance, without which many of the animal experiments could not have been performed.

TABULATION OF EXPERIMENTAL WORK.

The following detailed reports of the experiments are tabulated for reference:

TABLE 1.—TWENTY CASES SHOWING THE EFFECTS OF NITROUS OXID ANESTHESIA ON HEMOGLOBIN.

Case.	Duration of anesthesia.	Hb. % before.	Hb. % during.	Hb. % imdy. after.	Hb. % 24 hrs. after.
1	3′	75	85	75	*
2	5′	87	*	87	*
3	5′	90	90	85	*
4	5′	90	90	85	90
5	9′	78	80	68	*
6	10′	92	92	82	*
7	10′	70	*	70	*
8	10′	59	*	*	58
9	12′	65	*	65	73†
10	15′	67	*	60	65
11	15′	98	*	*	100
12	15′	69	76	69	*
13	15′	78	*	*	83
14	15′	70	90	65	65
15	15′	70	83	72	72†
16	20′	97	90	87	*
17	23′	86	*	80	93†
18	25′	98	120	88	*
19	25′	60	85	60	*
20	30′	70	75	60	70

* Record not taken.

† These readings were taken 48 hours after anesthesia.

TABLE 2.

Eight cases showing changes in hemoglobin (Hb.), erythrocytes (Erys.) and color index (C. I.) under nitrous oxid anesthesia.

Case and Duration of Anesthesia.	Blood Findings.	Before.	Immediately after.	24-48 hrs. after.	5-10 days after.
1.—10 min.	Hb.	59	*	58	66
	Erys.	4,688,000	*	4,280,000	4,148,000
	C. I.	.63	*	.68	.79
2.—12 min.	Hb.	65	65	73	*
	Erys.	4,024,000	4,400,000	4,928,000	*
	C. I.	.81	.79	.74	*
3.—15 min.	Hb.	98	*	100	103
	Erys.	5,392,000	*	5,524,000	5,380,000
	C. I.	.92	*	?	.97
4.—15 min.	Hb.	78	*	83	90
	Erys.	5,808,000	*	5,112,000	5,400,000
	C. I.	.67	*	.82	.83
5.—15 min.	Hb.	69	80	69	*
	Erys.	4,144,000	4,248,000	5,184,000	*
	C. I.	.84	.97	.67	*
6.—15 min.	Hb.	70	65	65	60
	Erys.	4,456,000	4,984,000	4,304,000	3,804,000
	C. I.	.79	.66	.75	.76
7.—15 min.	Hb.	70	72	72	76
	Erys.	4,096,000	4,824,000	4,992,000	4,616,000
	C. I.	.86	.75	.71	.82
8.—23 min.	Hb.	86	80	93	93
	Erys.	5,104,000	6,000,000	6,048,000	5,932,000
	C. I.	.84	.66	.77	.79

* Record not taken.

TABLE 3.

Seven cases showing the changes in hemoglobin, erythrocytes, color and volume indices, specific gravity and leucocytes (Lecy.) in a series of experimental animals under nitrous oxid anesthesia.

Case, duration, kind of anesthesia.	Blood findings.	Before anesthesia.	During anesthesia.	Immdy. after.	2 hrs. after.	24 hrs. after.	72 hrs. after.	6-9 days after.
	Hb.	98	116	95	*	96	98	98
	Erys.	6,968,000	7,712,000	793,600	*	7,040,000	6,784,000	7,100,000
	C. I.	.70	.75	.60	*	.68	.72	.69
1—40 min., gas and air.	Hm. Rd.	51	54+	55	*	51	50	51
	V. I.	.73	.70	.69	*	.73	.74	.72
	Sp. Gr.	1.062	1.064	1.067	*	1.067	1.058	1.061
	Lecy.	13,200	24,000	25,000	*	16,800	22,300	14,000
	Hb.	92	108	85	*	93	92	90
	Erys.	6,302,000	7,112,000	6,901,000	*	6,212,000	6,231,000	6,016,000
	C. I.	.70	.75	.62	*	.75	.74	.75
2—45 min., gas and air.	Hm. Rd.	45	53	55	*	50	48	46
	V. I.	.76	.74	.79	*	.80	.77	.76
	Sp. Gr.	1.060	1.064	1.062	*	1.059	1.059	1.059
	Lecy.	9,200	14,900	16,400	*	11,000	9,400	8,000
	Hb.	96½	104	91	95	98	97	*
	Erys.	6,120,000	6,700,000	6,100,000	6,180,000	6,350,000	6,200,000	*
3—45 min., gas and ¾ per cent. oxygen.	C. I.	.79	.78	.75	.76	.77	.78	*
	Hm. Rd.	55	58	55	55	54	55	*
	V. I.	.90	.87	.90	.90	.86	.89	*
	Sp. Gr.	1.054	1.056	1.055	1.054	1.055	1.055	*
	Lecy.	24,000	38,000	37,000	85,000	81,000	22,000	*

4—55 min., gas and 4½ per cent. oxygen.	Hb.	90	108	89	90.5	93	91	*
	Erys.	5,248,000	6,114,000	5,400,000	5,420,000	5,821,000	5,808,000	*
	C. I.	.86	.88	.82	.84	.80	.86	*
	Hm. Rd.	52	59	56	53	51	52	*
	V. I.	100	.97	103	.98	.90	.98	*
	Sp. Gr.	1.046	1.054	1.051	1.049	1.047	1.046	*
	Lecy.	6,200	11,600	10,500	10,000	8,300	7,000	*
5—1 hour, gas and air.	Hb.	92	109	84	*	93	92	*
	Erys.	5,960,000	6,600,000	7,186,000	*	6,480,000	6,100,000	*
	C. I.	.78	.82	.60	*	.72	.75	*
	Hm. Rd.	46	50	47	*	47.5	48	*
	V. I.	.79	.76	.66	*	.74	.79	*
	Sp. Gr.	1.055	1.059	1.063	*	1.058	1.058	*
	Lecy.	..	..	..	..	..	..	*
6—2 hrs. and 15 min., gas and air.	Hb.	85	108	84	86	86	85	86
	Erys.	6,400,000	7,552,000	6,816,000	6,410,000	6,380,000	6,250,000	6,480,000
	C. I.	.66	.72	.62	.67	.68	.69	.67
	Hm. Rd.	50	56	54	50	51	50	51
	V. I.	.78	.75	.79	.78	.81	.81	.79
	Sp. Gr.	1.063	1.065	1.063	1.063	1.063	1.062	1.063
	Lecy.	10,200	14,000	15,100	16,000	14,200	10,600	9,800
7—2 hrs. and 25 min., gas and air.	Hb.	88	118	84	87	91	92.5	88
	Erys.	6,944,000	8,268,000	7,256,000	7,010,000	6,800,000	6,800,000	6,380,000
	C. I.	.64	.72	.58	.62	.67	.68	.69
	Hm. Rd.	59	.63	.62	.60	.58	.58	.58
	V. I.	.86	.77	.86	.86	.85	.85	.91
	Sp. Gr.	1.055	1.065	1.066	1.056	1.056	1.055	1.055
	Lecy.	12,000	18,600	20,100	21,000	12,200	11,200	11,000

* Record not taken.

TABLE 4.

Summary of Table 3, showing changes in hemoglobin, erythrocytes, color and volume indices, specific gravity and leucocytes in a series of experimental animals under nitrous oxid anesthesia.

AVERAGE OF SEVEN CASES.

	Before.	During.	Immediately after.	2 hours after.	24 hours after	72 hours after.	6-9 days after.
Hb.	91.6	110.1	87.4	89.6	92.8	92.6	90.5
Erys.	6,271,000	7,142,000	6,771,000	6,250,000	6,428,000	6,235,000	6,450,000
C. I.	.71+	.77	.65	.71	.72	.74	.71
Hm. Rd.	.51	.56	.55	.51	.518	.51.6	.51.5
V. I.	.81	.79	.82	.81	.81	.82	.805
Sp. Gr.	1.056	1.061	1.061	1.0555	1.057	1.056	1.057
Lecy.	12,300	19,830	20,500	20,500	15,330	13,500	10,750

TABLE 5.

Comparison of blood findings in two cases of oxygen and nitrous oxid anesthesia with those in five cases of air and nitrous oxid anesthesia.

		Before.	During.	Immediately after.	2 hours after.	24 hours after.	72 hours after.	6-9 days after.
Average of oxygen and nitrous oxid cases.	Hb.	93.25	106	90	93	95+	94	
	Erys.	5,700,000	6,400,000	5,750,000	5,800,000	6,050,000	5,750,000	
	C. I.	.825	.83	.785	.80	.785	.81	
	Hm. Rd.	.535	.585	.555	.54	.525	.535	
	V. I.	.95	.92	.965	.94	.88	.935	
	Sp. Gr.	1.050	1.055	1.053	1.0515	1.051	1.0505	
	Lecy.	15,000	24,800	23,400	22,500	19,500	145,000	
Average of air and nitrous oxid cases.	Hb.	.91	112	.865	91+	918	918	.905
	Erys.	6,500,000	7,400,000	7,180,000	6,520,000	6,580,000	6,420,000	6,500,000
	C. I.	.70	.76	.61	.70	.70	.71	.69
	Hm. Rd.	.502	.552	5.46	.504	.514	.508	.515
	V. I.	.77	.74	.76	.77	.77	.78	.77
	Sp. Gr.	1.059	1.063	1.064	1.059	1.059	1.058	1.059
	Lecy.	10,800	17,500	19,000	19,200	18,250	13,000	10,250

TABLE 6.

Comparison of blood findings in two cases of prolonged nitrous oxid anesthesia with two cases of moderate length nitrous oxid anesthesia.

Cases.	Blood Findings.	Before.	During.	Immediately after.	2 hours after.	24 hours after.	72 hours after.	6-9 days after.
Average of two cases over two hrs.; gas and air.	Hb.	.865	113	84	.865	.865	.885	.87
	Erys.	6,700,000	7,900,000	7,000,000	6,700,000	6,600,000	6,500,000	6,400,000
	C. I.	.65	.72	.60	.645	.675	.685	.68
	Hm. Rd.	.545	.595	.58	55	.545	54	.545
	V. I.	.82	.76	.825	.82	.83	.83	.85
	Sp. Gr.	1.059	1.065	1,0645	1.0595	1.0595	1.0585	1.059
	Lecy.	11,000	16,300	17,500	18,500	13,100	10,700	10,400
Average of two cases 40-45 min.; gas and oxygen.	Hb.	95	112	90	....	.945	95	94
	Erys.	6,650,000	7,400,000	7,400,000	....	6,600,000	6,500,000	6,550,000
	C. I.	.715	.755	.61	....	.715	.73	.72
	Hm. Rd.	.48	.535	55	....	.505	.49	.485
	V. I.	.72	.72	.74	....	.76	.755	.74
	Sp. Gr.	1.061	1.064	1.0645	....	1.060	1.058+	1.060
	Lecy.	10,600	19,450	20,700	....	13,900	16,350	11,000

TABLE 7.

Table showing the difference between the Dare and von Fleischl readings of hemoglobin during nitrous oxid anesthesia.

	Readings.	Before anesthesia.	During anesthesia; 16 min.	During anesthesia; 25 min.	During anesthesia; 45 min.	During anesthesia; 70 min.	Average.
Dog. gas and air.	Erys.	5,576,000	5,832,000	6,328,000	6,336,000	6,200,000	6,170,000
	Hb.—Dare.	97	108	119	115	114	114
	Hb.—von F.	96	99	108	108	106	104.7
	C. I.—Dare.	.87+	.93+	.94+	.91+	.92+	.92+
	C. I.—von F.	.86+	.85.4	.86—	.86	.86—	.85

TABLE 8.

Table shows the difference in the hemoglobin percentage as taken by the Dare instrument of the blood withdrawn from three dogs during nitrous oxid anesthesia before and after it had been oxidized by passing pure oxygen through it for five minutes.

	Dog 1.		Dog 2.		Dog 3.	
	Before.	After	Before.	After.	Before.	After.
	110	98	120+	85	116	90
	114	96	120+	82	109	88
	112	97	120+	84	108	86
	109	96	120+	81	114	92
	112	95	120+	87	118	95
Av.	111 4	96.4	120	83.8	113	90.2

TABLE 9.

Five cases showing blood changes during ether anesthesia. Five animal experiments.

Case and duration of anesthesia.	Blood Findings.	Before anesthesia.	Immediately after mask removed.	24 hours after.	72 hours after.	5-7 days after.	8-10 days after.
	Hb.	97	97	98	97	97	96
	Erys.	6,216,000	6,196,000	6,880,000	6,321,000	6,402,000	6,302,000
1.—Ether, 15 min.	C. I.	.78	.78	.74	.77	.76	.77
	Hm. Rd.	56	55	57	55	55	55+
	V. I.	.90	.90	.84	.87	.88	.87
	Hb.	85	100	96	97	84	76
	Erys.	4,416,000	5,728,000	6.072,000	6,200,000	6,002,000	4,732,000
2.—Ether, 70 min.	C. I.	.966	.87	.84	.78	.70	.67
	Hm. Rd.	46	49	45	45	43+	46
	V. I.	1.04	.86	.75	.73	.72	.81
	Hb.	98	104	102	101	96	92
	Erys.	6,100,000	6,410,000	6,340,000	6,200,000	6,000,000	5,908,000
3.—Ether, 25 min.	C. I.	.78	.81	.81	.81	.80	.78
	Hm. Rd.	55	58	57	55	55	54
	V. I.	.90	.90	.90	.89	.91	.91
	Hb.	91	108	104	99	97	94
	Erys.	5,704,000	6,900,000	6,712,000	6,624,000	6,501,000	6,080,000
4.—Ether, 1 hour.	C. I.	.80	.78	.78	.76	.75	.78
	Hm. Rd.	46.5	55	50	50	48	47
	V. I.	.82	.80	.75	.76	.75	.78
	Hb.	87	97	95	95	82	81
	Erys.	5,512,000	6,502,000	5,824,000	5,344,000	5,888,000	5,108,000
5.—Ether, 2 hours, 28 min.	C. I.	.85	.75	.82	.89	.71	.79
	Hm. Rd.	48	54	48	44	48	47
	V. I.	.94	.83	.83	.83	.83	.91
	Hb.	91	101	99	98	91	88
	Erys.	5,500,000	6,320,000	6,320,000	6,120,000	6,160,000	5,600,000
Average of above tables.	C. I.	.83	80	78	80	75	78
	Hm. Rd.	50.2	54.2	51.4	506	.498	.498
	V. I.	.91	.86	.81	.83	.81	.898

TABLE 10.

Five cases showing blood changes during chlorform anesthesia. Five animal experiments.

Case and duration of anesthesia.	Blood Findings.	Before anesthesia.	Immediately after.	24 hours after.	3-5 days after.	7-10 days after.
	Hb.	98	102	108	93	88
	Erys.	7,264,000	7,300,000	8,368,000	6,488.000	6,816,000
1.—Chloroform, 18 min.	Col. In.	.61	.69	.60	.68	.64
	Hm. Rd.	51	53	59	52	51
	Vol. In.	.71	.72	.71	.76	.74
	Hb.	90	91	104	87	92
	Erys.	6,400,000	6,744,000	7,744,000	6,848,000	6,430,000
2.—35 min.	Col. In.	.70	.68	.68	.64	.71
	Hm. Rd.	42	46	49	43	42
	Vol. In.	.66	.70	.64	.63	.66
	Hb.	98	99	107		
	Erys.	6,632,000	7,420,000	8,552,000		
3.—1¾ hrs.	Col. In.	.74	.68	.62		
	Hm. Rd.	51.5	55	65		
	Vol. In.	.77	.74	.76		
	Hb.	88	91	93	90	84
	Erys.	6,880,000	7,304,000	7,648,000	6,800,000	6,328,000
4.—2 hrs. 10 min.	Col. In.	.64	.62	.61	.66	.67
	Hm. Rd.	47	47	485	465	47
	Vol. In.	.69	.64	.64	.68	.72
	Hb.	98	95	99	88	80
	Erys.	6,160,000	6,432,000	6,478,000	6,394,000	5,600,000
5.—2 hrs. 45 min.	Col. In.	.80	.74	.78	.70	.71
	Hm. Rd.	49	50	475	46	48
	Vol. In.	.80	.80	.74	.73	.78
	Hb.	94.4	928	102.2	89.5	86
	Erys.	6,620,000	7,020,000	7,700,000	6,675,000	6,275,000
	Col. In.	.71	.68	.66	.68	.69
	Hm. Rd.	481	502	536	47	456
	Vol. In.	.73	.71	.60	.71	.78

TABLE 11.

Cases showing effect of nitrous oxid anesthesia on coagulation time of blood. Fifteen clinical cases.

Case.	Duration of anesthesia.	Coag. time before.	24 hrs. after.	72 hrs. after.	6-7 days after.	10-14 days after.
1	10 min.	6	7¾	7¾	8	7½
2	12 min.	9½	9¾	9½	9¼	10
3	15 min.	6¾	6½	6¼	6½	6¼
4	18 min.	5½	5½	6	...	6½
5	18 min.	4	...	4½	4½	5½
6	18 min.	5¼	...	4¾	3¼	5
7	24 min.	4½	5½	8	7¾	7¾
8	25 min.	7¼	7½	7	4¼	5
9	25 min.	8¼	8¾	9	9½	8
10	25 min.	7	7¾	...	...	...
11	30 min.	9¾	9¾	9	9½	10
12	32 min.	6½	6¾	8½	8¼	6¾
13	38 min.	6½	6	...	6¼	6½
14	40 min.	5¼	6½	6½	6	5
15	43 min.	3¾	4	4¾	5	4
Aver.,	24.8	6.36	7.07	7.19	6.76	6.69

TABLE 12.

Table showing the effects of ether anesthesia on the coagulation time of blood. From twenty-five clinical cases.

Case.	Anesthesia duration.	Before.	24 hrs. after.	72 hrs. after.	5-6 days after.	7-10 days after.	11-18 days after.
1	10"	6½	6¼	6½	6	6	6¾
2	12"	5¼	5½	5¾	5¾	5½	5
3	15"	5	5	4½	4¼	4¼	5
4	28"	5¼	6¾	4¾	3¾	3½	5
5	36"	7	7½	6½	4½	5	5
6	40"	10½	...	8	6¾	5¼	9
7	40"	8	...	6½	5¾	3½	...
8	40"	5¾	6	...	4½	4	...
9	40"	9½	9	7½	5¼	4¾	...
10	41"	4	4	3	...	2¾	4½
11	45"	13	10¼	...	...	5½	...
12	45"	7½	5¼	5¼	4¼	8	7¾
13	48"	7	7	5¼	3¾	3½	4¾
14	50"	4¾	4½	4¾	...	2¼	7
15	50"	10	8	5¼	4¾	3¼	5½
16	55"	7¼	6½	7¾	6¼	...	6½
17	63"	9	8½	...	4¼	2¾	4
18	75"	6	5½	...	4	4	...
19	75"	8½	8	7¾	5¼	3¾	6
20	80"	18	...	...	9½	5¼	14
21	86"	6½	4½	4½	3½	3	4
22	90"	10	...	...	6¾	4	9
23	95"	5	4¾	5½	5¾	6	5
24	105"	4½	4½	4	3½	2½	4¾
25	110"	3¾	3¾	3½	3	2½	4
Aver.,	54.9"	7.04	6.24	5.43	5	4.16	6.1

TABLE 13.

Showing effect of nitrous oxid anesthesia on the coagulation time of blood. Five animal experiments.

Case.	Duration of anesthesia.	Coag. time before.	24 hrs. after.	72 hrs. after.	5-6 dys. after.	7-10 dys. after.
1	40"	4	4½	4¼	3¾	4½
2	45"	5	5¼	6	5½	5
3	60"	3	4¾	5¼	4½	4
4	135"	2¾	3½	3¾	4½	3
5	145"	2½	4½	4¾	3¾	2¼
Averages,	85"	3.45	4.5	4.8	4.3	3.75

TABLE 14.

Showing the effect of ether anesthesia on coagulation time. Fifteen animal experiments.

	Duration of anesthesia.	Coag. time before.	24 hrs. after.	72 hrs. after.	5-6 days after.	7-10 days after.	11-15 days after.
1	15 min.	2¾	2¾	2¾	2¾	2¼	..
2	55 min.	5¼	4¾	3¾	2½	1½	..
3	70 min.	3¾	3½	2	1¾	1¼	..
4	105 min.	3	2¾	3¼	2¾	1¾	3
5	148 min.	5¼	3¾	3¼	1¾	2	3
6	40 min.	4	3¾	3¼	3	1¾	..
7	40 min.	4	3¼	2¾	2½	2¾	..
8	55 min.	5¼	5	3¾	1½	2	..
9	60 min.	4½	3¼	2¾	...	2½	..
10	90 min.	5½	4¾	2¾	2½	1¾	..
11	45 min.	2½	2½	2¼	1½	1¼	..
12	50 min.	3½	2½	2½	2	1¼	..
13	50 min.	3¼	3¾	2¾	2½	1½	..
14	60 min.	2½	2½	3	2½	1¾	..
15	85 min.	4½	4¼	3	2½	3	..
Aver.,	64 min.	3.96	3.30	2.89	2.28	1.88	..

TABLE 15.

Showing the effect of chloroform anesthesia on the coagulation time of the blood. Five animal experiments.

Case.	Duration of anesthesia.	Coag. Time before.	24 hrs. after.	72 hrs. after.	5-6 days. after.	7-10 days after.
1	18 min.	2¾	3¾	3¾	3¾	3
2	35 min.	5½	4¾	4½	4	4¾
3	105 min.	3¾	3½	3	3¼	2¾
4	130 min.	4¼	3¼	4½	3¼	3¼
5	165 min.	4¾	3¼	3½	3½	3¼
Aver.,	90 min.	4.2	3.70	3.85	3.47	3.40

DECAPSULATION OF THE KIDNEYS FOR CHRONIC BRIGHT'S DISEASE.

WITH A REPORT OF THE RESULTS, IMMEDIATE AND REMOTE, OBTAINED IN 102 CASES THUS TREATED.*

GEORGE M. EDEBOHLS, M.D.

NEW YORK.

When, in 1901, I suggested treating chronic Bright's disease by decapsulation of the kidneys, I placed myself under a moral obligation to report the results after a sufficient length of time had elapsed. In fulfilment of this obligation the present report is submitted:

The working theory on which I based my procedure of renal decapsulation for chronic Bright's disease was that by the removal of the impervious capsule an opportunity was created for the formation of new vascular connections between the blood vessels supplying the secreting structures of the kidney on the one hand and the blood vessels and tissues surrounding the kidney on the other. An additional blood supply is thus created for the kidney. The increased blood supply and activity of circulation are depended on to improve the working coefficient and gradually to restore the health of the kidney.

My observations on the kidneys of some of my patients who have died months and years after decapsulation, or whose kidneys I have decapsulated a second—and in one instance a third—time, have invariably demonstrated the formation of a more or less abundant new blood supply as the result of operation. While the creation of a new blood supply to the kidney readily explains the clinically established fact of con-

tinued and lasting improvement in the work of a diseased kidney after decapsulation, it fails to explain fully and satisfactorily the immediate beneficial effects so often witnessed. I have never in any of my operations for chronic Bright's disease found the capsule tightly stretched and compressing the kidney. Generally it fits the kidney, and sometimes the kidney even appears to be somewhat shrivelled or contracted within the loosely fitting capsule. Even in far-advanced chronic interstitial nephritis with greatly thickened capsule, the reduction in size of the kidney appears to be due rather to contraction of the new fibrous interstitial tissue of the kidney itself than to compression of the capsule. I believe that the immediate good effects of decapsulation can be explained by the necessary manipulation, amounting in reality to a massage of the kidney, during operation. The immediate stimulation of the existing blood supply of the kidney thus effected, supplemented by the relief to congestion afforded by the direct abstraction of more or less blood from the organ during operation, suffices for the immediate needs of the kidney and carries it along until its supplementary new circulation becomes established. If we can cure chronic Bright's disease by renal decapsulation we can well afford to wait until time and further observation bring the explanation of the exact physiologic effects of the operation.

One invariable effect of renal decapsulation is the formation of a new capsule. This becomes distinctly organized in from three weeks to three months, is sometimes thicker, sometimes thinner, but always more succulent and vascular than the original. It has been suggested that this new capsule must inevitably contract and lead to injurious compression of the kidney with a return of the symptoms. This argument is not based on actual observation, nor is it in harmony with the results of animal experimentation, or with the clinical facts. I now give but little thought to the question of possible

danger of contraction of the new capsule. The immediate effect of decapsulation is to increase the daily output of urea and cause the disappearance or lessening of uremic manifestations. I have known a daily excretion of 6 grams or less of urea, prior to operation, to be increased to a steady output of 30 to 35 grams within a month after operation.

Renal decapsulation enables any given kidney to do the best work which it is possible for that particular kidney to do. I now decapsulate every kidney operated on for any purpose, and believe that the other kidney should be explored and decapsulated before completing a nephrectomy. For the purposes of this report the diseases of the kidney are classified as: first, interstitial nephritis, those cases in which the gross evidences of inflammation of the connective tissue of the kidney predominate; second, parenchymatous nephritis, those in which the involvement of the secretory apparatus forms the salient feature; and, third, diffuse nephritis, those inflammations of the kidney characterized by implication in fairly equal degree of both the parenchyma and the connective tissue of the organ.

The diagnosis of chronic nephritis on the living subject is easy after some experience, the pathologic changes being more appreciable with the blood circulating through the kidney than they are after death. It is easy to recognize in the adherent capsule, nodulation, granular condition of the subcapsular surface, shrinking, unequal contraction, and occasional cyst formation, a chronic interstitial nephritis; or by the enlargement, cloudy swelling, mottling, and discolorations due to circulatory and degenerative changes, a chronic parenchymatous nephritis; or by the thickening, general or localized, of the capsule, and the secondary inflammatory changes in the perirenal fat common to both varieties, a chronic diffuse nephritis. The variations in density and hardness, quite frequently varying widely in different parts of the same organ, are also readily

appreciated. I now find no difficulty in promptly determining at operation whether or not a kidney is affected with chronic Bright's disease.

I now advise renal decapsulation for every sufferer who consults me for chronic Bright's disease, and who has a reasonable expectation of not less than a month of life without operation. The three conditions which lead me to advise renal decapsulation are: First, the clear and unequivocal establishment of the diagnosis of chronic Bright's disease; second, the absence in a given case of absolute contraindications to any operation; third, the possibility of securing the services of a surgeon practically familiar with the surgery of the kidney.

As soon as a nephritis has become chronic it is an absolute indication for decapsulation. The earlier in the course of chronic nephritis an operation is performed the better will be the patient's chances of a perfect cure. Renal decapsulation is indicated in all varieties of chronic nephritis. I no longer advise against operation on account of .advanced age, provided the patient be otherwise in reasonably fair condition. It must be borne in mind that all patients with chronic Bright's disease have more or less hypertrophy of the heart. As long as the enlargement is mainly hypertrophic and not due to dilatation, and as long as the hypertrophy is concentric, an anesthetic may be administered with a reasonable degree of safety. It is only when dilatation of the heart predominates over the hypertrophy that the danger of sudden death from acute dilatation is ever present, and no general anesthetic should be administered to such a patient. In my opinion the most ominous auscultatory sign of predominant dilatation of the heart and danger of sudden death is insufficiency of the aortic valves, as denoted by an intermittent aortic regurgitant murmur occurring every third, fourth, or fifth beat, and even less frequently. When this condition is clearly present and can not be removed by suitable medication, the patient is very near

the end of life and I advise against operation. During the course of recent years I have had the unexpected pleasure a number of times, on examining patients at periods remote from operation, of finding that very pronounced cardiac hypertrophies and derangements had become totally insignificant, and in some cases had even entirely disappeared, as the health of the kidneys was gradually regained. These changes for the better in the condition of the heart I have come to regard as the surest indication that the health of the kidneys is improving.

Retinitis albuminurica demands careful consideration in determining for or against renal decapsulation. Edema or dropsy of the retina must be differentiated from true retinitis with hemorrhage or exudates. The former may disappear, the same as a dropsy in any other part of the body. The importance of true retinitis albuminurica in relation to renal decapsulation lies in the fact that it is one of the late manifestations of chronic Bright's disease. Its occurrence signifies that the general changes produced throughout the body by the disease are so far advanced that they will cause death, even though the function and health of the kidneys can be restored by operation. It also indicates such widespread disease of the vascular system that the danger of rupture of blood vessels in any part of the body is always imminent. Among the first 72 patients, 9 had retinitis albuminurica at the time of operation. The unfavorable outcome in these cases has led me for the past three years to decline to operate on patients who had well-marked albuminuric retinitis. The only point that requires emphasis in the operation is the necessity of securing union by first intention.

The changes in the patient's condition and general health after decapsulation are nearly always impressive, and in some cases simply marvellous. The improvement is progressive, continuing and increasing even after the patient has resumed his usual avocation. This

is due to the improved work of the kidneys, as denoted especially by the increased daily urea output.

My own experience with renal redecapsulation has thus far not been very encouraging. Were it not for the impression created by the case of Peabody, I should feel opposed to further trial of a second decapsulation in cases in which the first operation failed to initiate the cure. The only indication for a second decapsulation that would appeal to me would be in the case of a patient acquiring a new chronic nephritis after having been entirely cured of a first chronic nephritis by the first decapsulation.

Renal decapsulation for puerperal convulsions of renal origin are really renal decapsulations for subacute or chronic nephritis, at least that has been my experience.

Whatever merit may be claimed for or accorded this report of the result of my renal decapsulations for chronic Bright's disease must be based entirely on the fidelity and persistence of purpose with which the histories and postoperative fortunes of my patients have been followed and recorded. This report embraces all my operations performed on the kidneys with the hope of curing or improving existing chronic Bright's disease up to the end of May, 1906, the patients numbering 102 all told. Nearly fifteen years have elapsed since the first operation, and fifteen months represent the shortest period of observation after operating in any of the surviving cases—an average of five years for each of the 102 cases has elapsed since operation. All but 3 of the 102 patients are fully accounted for; the 3 cases unaccounted for were lost sight of years ago.

With 99 of my 102 patients I have managed to keep in touch continuously from the day of operation until either the date of their death or the present day. In the case of those who died, I have succeeded in obtaining the exact date as well as the cause of death in each instance. The vast majority of my cases were private;

scarcely half a dozen belong to the class of hospital-ward cases. This has been of material assistance in following the after history of these patients. The patients themselves have freely and voluntarily cooperated in the attempt to solve the question of the curability of chronic Bright's disease. Whenever I have failed to hear from a patient for a period of six months I have made inquiry either of the patient or of the attending physician. I consider myself exceptionally fortunate in having succeeded in obtaining from all but one or two a twenty-four-hour specimen of urine at fairly regular intervals of time since the operation. The last specimen of urine from all but three of the survivors has been obtained within the past few months.

SUMMARY OF CASES.

Since the publication of my book in 1904 I have continued to follow and record the further histories and fortunes of my surviving patients, as well as of those operated on in 1904, 1905, and the first half of 1906. I have thus managed to keep together this entire clinical material as a compact whole. I fully realize that in order to obtain recognition and acceptance by the profession at large for the surgical treatment of Bright's disease a sufficiently large number of cases of chronic nephritis observed for a sufficient length of time after renal decapsulation was an absolute essential. I believe that this report will show that this purpose has now been fulfilled. This report will probably be my final one,[1] and it is hoped that it will be received and accepted by the profession in full and complete discharge of the moral obligation assumed by myself when I first proposed to treat chronic Bright's disease, as such, by surgical measures.

SEX.

Of my 102 patients 50 were male and 52 female.

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1. Dr. Edebohls died Aug. 8, 1908.

AGE.

The youngest patient was 4½ years, the oldest 67 years of age. The average age of the 102 patients at the time of operation was 39 years and 8 months.

OCCUPATION.

Notes concerning the occupation of patients were rarely made, the matter not being deemed of sufficient practical interest. Fourteen of my patients were themselves physicians, and five were immediate members of physicians' families.

HISTORY PRIOR TO OPERATION.

The majority of the patients at and before the time of operation presented either all or the most serious of the well-known clinical features of the disease. Some suffered in one way or another without having such a pointed history as unmistakably to indicate chronic Bright's disease. A few were absolutely unaware of any serious impairment of health until the occurrence of paralysis, of retinitis albuminurica, of uremic convulsions, or the discovery of albumin and casts in the urine on application for life insurance brought them suddenly face to face with the fact that they were affected with a fatal malady. It is a well-known fact that chronic Bright's disease frequently develops and progresses in an insidious manner, so that the advanced and final stages of the malady are often reached before the patient is aware that there is anything greatly wrong.

PHYSICAL CONDITION AT TIME OF OPERATION.

Equally great with the differences in the symptoms produced by the disease were the physical manifestations and objective signs presented by the various patients on examination prior to operation. In comparatively few there were absolutely no manifestations of chronic nephritis except such as examination of the urine revealed. Others, again, suffered from all conceivable ravages of the disease in distant parts of the body—the brain, the visual organs, the heart and lungs, the digestive system, etc. Between the two extremes mentioned all shades of variation were encountered.

LENGTH OF EXISTENCE OF CHRONIC BRIGHT'S DISEASE PRIOR TO OPERATION.

One of the most difficult things to determine is the exact date of the beginning of chronic nephritis. Perhaps the only time when this can be done with absolute exactness is when the chronic nephritis is the outcome or the continuation of an

acute nephritis occurring either as a primary affection or as a complication of other diseases: influenza, scarlatina, typhoid fever, diphtheria and other general infections in which the kidneys are liable to become involved. Even then our conclusion that the nephritis dates from such an event may not be correct. The patient may have had chronic nephritis prior to the occurrence of the infectious disease, and the acute nephritis supposedly induced by the infection may in reality have been only an acute exacerbation of an already existing nephritis. Uncertainty in this respect pertains even to those cases of nephritis which the history indicates as having originated during a pregnancy.

Subject to the restrictions and limitations just stated, an attempt has been made to determine the probable duration of the chronic nephritis prior to operation in each patient from the length of time that the symptoms have existed. Judged by this admittedly defective standard, the average duration of chronic Bright's disease prior to operation in my 102 cases was four years. That the average duration, as thus estimated, falls far within the real limits is very certain.

In 85 of the 102 patients the period of time prior to operation at which examination of the urine first revealed the presence of chronic Bright's disease could be accurately determined. In these 85 patients the duration of chronic Bright's disease prior to operation, as known from urinalysis averaged 2 years and 11 months.

DATE OF OPERATION.

The first of my 102 patients was operated on Nov. 29, 1892; the last on May 31, 1906. Nearly fifteen years have passed since the first operation, and fifteen months have elapsed between the last operation and the date of this report.

PLACE OF OPERATION.

One hundred and nine operations were performed on the kidney or kidneys of my 102 patients, 7 of the patients having two kidney operations. The 109 operations were performed in the following places:

My private hospital	40
New York Postgraduate Hospital	37
Home of the patient	15
St. Francis Hospital, New York	14
Galt General Hospital, Galt, Ontario, Canada	1
Dr. H. D. Fry's private hospital, Washington, D. C.	1
Virginia Hospital, Richmond, Va	1

NATURE OF OPERATIONS PERFORMED ON THE KIDNEYS.

	Sittings.	Patients.	Operations.
Decapsulation of both kidneys....	1	69	69
Redecapsulation of both kidneys..	1	..	4
Decapsulation and fixation of both kidneys	1	17	17
Decapsulation and fixation of both kidneys	2	2	4
Decapsulation of both kidneys and fixation of right kidney........	1	4	4
Decapsulation of one kidney and removal of the other...........	1	2	2
Decapsulation of one kidney and removal of the other..........	2	1	2
Decapsulation and fixation of right kidney	.	7	7

It will be noted that in 7 cases only one kidney, always the right, was operated on; while in 95 cases both kidneys were submitted to operation. Ninety-two of the 95 bilateral operations were performed at one sitting; in three instances the right and left kidneys were operated on at two separate sittings. Both kidneys of two patients were decapsulated twice, and both kidneys of one patient three times.

ANESTHETIC.

The following list shows the number of operations in which each of several anesthetics was employed, alone or in combination:

Nitrous oxid and ether...........................	63
Ether	19
Chloroform	11
Chloroform and ether..............................	4
Chloroform and oxygen............................	1
Nitrous oxid and chloroform........................	1
Nitrous oxid, ether and chloroform.................	1
Nitrous oxid, oxygen, ether and chloroform..........	1
Nitrous oxid and oxygen...........................	8

I have had the good fortune in the majority of these 109 operations to have at my command the services of specialists and acknowledged experts in the administration of anesthetics, and when such was the case the choice of anesthetic was left with the anesthetist. I can see no good reason, however, why any surgeon should not use in his kidney operations the same anesthetic to which he is accustomed in his operative work generally. To this broad rule there are exceptions, special reasons for the preference of a particular anesthetic being now and then given by the predominance of particular complications, especially those affecting the heart, lungs and vascular system. Under these conditions the choice of anesthetic must be made on generally understood and accepted principles, and

it should always be borne in mind that in operations on the kidneys of patients suffering from chronic nephritis the danger is, broadly speaking, greater from the anesthesia than from the operation.

ADDITIONAL OPERATIONS.

A number of operations additional to the kidney operations were performed by me on a certain proportion of the 102 patients. The additional operations, although many of them were of a severe character, were attended with no mortality. In some instances the kidney and the additional operation or operations were performed at the same sitting; in some the additional operation or operations either antedated or followed operation on the kidneys.

VARIETY OF NEPHRITIS AS ESTABLISHED AT OPERATION.

Right and left chronic interstitial	31
Left chronic interstitial, right kidney normal	4
Right chronic interstitial, left kidney normal	1
Right and left chronic diffuse	34
Left chronic diffuse, right kidney normal	3
Right chronic interstitial, left chronic diffuse	6
Right and left chronic parenchymatous	16
Right chronic diffuse, left kidney not operated on	1
Right chronic interstitial, left kidney not operated on	6

The only difficulty in the classification of the variety of nephritis that presented itself was in the cases of three patients whose kidneys were decapsulated for the cure of puerperal convulsions. In these three cases a subacute parenchymatous nephritis was encountered. As there was much evidence, however, both from the condition of the kidneys and in one case from the history of the patient, that the subacute nephritis encountered at operation was but an exacerbation of a previously existing chronic nephritis, these cases have been classified under the head of chronic parenchymatous nephritis.

From the above classification it will be seen that one variety of nephritis may affect one kidney, and a second variety the other kidney of the same individual—right chronic interstitial and left chronic diffuse nephritis having been observed no less than six times.

UNILATERAL NEPHRITIS.

Chronic nephritis affecting one kidney only was noted in a strikingly large proportion of the 102 cases. In 8 patients, in whom both kidneys were exposed at operation, one kidney was found healthy and the other diseased, the unilateral chronic nephritis being of the interstitial variety in 5, and of

the diffuse variety in 3 cases. Of 7 patients in whom only one kidney was operated on, 4 were completely cured of their former chronic interstitial nephritis and have remained cured for periods of time varying between five and fourteen years; therefore, these 4 patients must either be regarded as having had a healthy kidney on the side not operated on, or, if it be assumed that the second kidney also was diseased at the time of operation, the decapsulation of one of a pair of diseased kidneys must be credited not alone with restoring the health of the kidney operated on, but of that of its fellow kidney as well. I incline to the former of these two explanations as the more probable. In 8 of the 102 cases, therefore, the chronic nephritis was proved beyond a reasonable doubt to be confined to one kidney, and that such was the case in at least 4 other patients the final outcome makes extremely probable. These observations I am compelled to interpret as establishing beyond controversy the fact that chronic nephritis may be encountered as a unilateral affection in a hitherto unsuspected proportion of cases.

RENAL AND PERIRENAL CONDITIONS COMPLICATING THE CHRONIC NEPHRITIS.

Polycystic degeneration of left kidney	3
Polycystic degeneration of right kidney	1
Bilateral pyelonephritis, with miliary abscesses	2
Unilateral pyelonephritis, with miliary abscesses	1
Left acute suppurative perinephritis	1
Right chronic perinephritis	5
Right and left chronic perinephritis	14

WOUND HEALING.

Of the 205 lumbar incisions made in the 109 operations on these 102 patients, 200 healed by primary union throughout. The failure to obtain primary union in the remaining five incisions was due to the following causes:

One intractable patient infected both wounds by repeatedly tearing off all dressings	2
Breaking down of an acute perinephritis antedating operation	1
Suppuration of a deep perirenal hematoma	1
Slight leakage of urine from surface of kidney	1

In not a single case was the breaking down of the wound the result of infection introduced at operation.

ANALYSIS OF RESULTS.

Of the 102 patients 10 died within two weeks following operation, 39 died at periods of time more or less remote from operation, 3 disappeared from observation after leaving the hospital, and 50 are known to be living.

OPERATIVE MORTALITY.

The operative mortality may be stated as 9.8 per cent. In reality, however, as 7 patients were operated on twice, 109 operations were performed on one or both kidneys. One of these patients died after a second decapsulation. Figured in this way, there were 11 deaths in 109 renal decapsulations for chronic Bright's disease, an operative mortality of 10.1 per cent. In round numbers, therefore, my operative mortality was 10 per cent.

This 10 per cent. mortality is fairly attributable to the disease itself and to its complications rather than to the operation. Bilateral renal decapsulation could be performed by an expert in renal surgery on 100 perfectly healthy human beings without losing a single life. In judging my own mortality, the fact must be taken into consideration that for one reason or another I accepted for operation cases in which the fatal outcome was almost a foregone conclusion. Patients, as well as their physicians (the two sometimes represented in the same person), insisted that they were entitled to the benefit of the doubt, and requested or even demanded operation.

Six of the operative deaths occurred in the first 40, 5 in the last 69 operations. All of the 10 patients who died within fifteen days following operation were males. The average age of the 10 patients was 45 years and 6 months.

The average duration of chronic nephritis prior to operation in these 10 patients, as indicated by the symptoms, was 4 years 11.6 months; as known from urinalysis, 3 years 1.7 months.

Decapsulation of both kidneys at one sitting was performed on each of these 10 patients.

Of the 10 patients, 7 suffered from chronic interstitial nephritis, 2 from chronic diffuse nephritis, and one from chronic parenchymatous nephritis, the disease in every instance being bilateral.

The cause of death was acute dilatation of the heart in 4 cases, uremia in 3, cerebral hemorrhage and uremia in 1, acute dilatation of the heart and edema of the lungs in 1, and acute lobar pneumonia in 1.

LATER DEATHS.

Thirty-nine patients died at periods of time more or less remote from operation and from causes in no wise connected with the operation; of these 26 were males and 13 females.

The average age of the 39 patients at the time of operation was 41 years and 10 months.

The average duration of chronic nephritis prior to operation in these 39 patients, as indicated by the symptoms, was 4 years 7.3 months; as known by urinalysis, 2 years 7 months.

Decapsulation of both kidneys was performed on 24 of these patients; decapsulation and fixation of both kidneys on 2; decapsulation of both kidneys with fixation of the right on 1; decapsulation and fixation of the right kidney on 1; decapsulation of the right kidney and removal of the left on 1.

Of the 39 patients, 17 suffered from right and left chronic interstitial nephritis; 1 from right chronic interstitial nephritis; 3 from right chronic interstitial and left chronic diffuse nephritis; 8 from right and left chronic diffuse nephritis; 2 from left chronic diffuse nephritis; 1 from right chronic diffuse nephritis, and 7 from right and left chronic parenchymatous nephritis.

Wound healing was by primary union throughout in each of the 77 incisions made on these 39 patients.

Of the 39 patients, 1 died as the result of abdominal hysterectomy eight years after her kidney operation; 1 died of an operation for ruptured tubal pregnancy one year after operation on her kidneys; 1 died of septic pneumonia due to suppurative coxitis; 1 died of chronic pleuropneumonia; 1 died of gangrene of the tonsils and palate following grip; 1 died of cerebral embolism in the course of grip; 1 died of heart failure and uremia in the course of grip; 3 died of cerebral hemorrhage; 1 died of suppurative pyelonephritis; 4 died of edema of the lungs; 1 died of endocarditis; 2 died of valvular disease of the heart; 4 died of acute dilatation of the heart; 1 died of diabetic gangrene of the lower extremities, and 16 died of uremia.

Of these 39 later deaths, 10 were due to causes that stood in no direct relation to chronic nephritis—2, for instance, died of diabetes. Three other patients succumbed to grip. Including these last 3 cases, 29 of the 39 later deaths may fairly be ascribed to chronic nephritis and to its sequelæ and complications.

The longest period of time between operation and death was eight years; the shortest, fifteen days. The average duration of life after operation was 1 year 4 months and 20 days.

In these 39 patients, 11 received no benefit from the operation; in 1, the possible benefit from operation was prevented by suppurative coxitis; the complications of the advanced stages of chronic Bright's disease nullified the benefits of operation in the remaining 10.

Four experienced slight and temporary improvement only. A peculiar feature of this temporary improvement consisted in the fact that the patient's general health and well-being were decidedly improved, so much so that three of the four who were bedridden for months preceding operation were able to return to work and to remain at work until within a very short time before death. This improvement in general health, however, was not accompanied by any improvement in the condition of the kidneys. Albumin and casts continued in the same or even greater abundance than before operation. The daily output of urea, however, was always greater than before operation, and the consequent lessening of uremia probably explains the improvement in general health and well-being. In other words, the functional activity of the kidneys was temporarily improved by decapsulation, although the fatal organic changes continued unchecked.

Eight patients experienced moderate improvement, the average duration of such improvement amounting to 1 year and 10 months.

Sixteen patients experienced decided improvement, lasting in 3 cases until death from causes other than chronic nephritis. The average duration of decided improvement for these 16 cases was 1 year and 2 months.

THE SURVIVORS.

There are 53 survivors. The youngest was 4 years and 7 months, and the oldest was 67 years of age at the time of operation. The average age of the 53 survivors at the time of operation was 38 years and 11 months. An average period of fully five years for each of the survivors has elapsed since operation, making the average age of the survivors at the present time (September, 1907) 43 years and 11 months.

The average duration of chronic nephritis in the 53 survivors, as judged from the history and symptoms, was 3 years 6.9 months. The average period before operation at which albumin and casts were first discovered in the urine was 3 years 1.2 months.

The following operations were performed on the 53 survivors:

Decapsulation of both kidneys	25
Decapsulation and fixation of both kidneys	17
Decapsulation of both kidneys and fixation of right kidney	3
Decapsulation and fixation of right kidney	6
Decapsulation of right kidney and left nephrectomy	2

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The 53 survivors had, and a number of them still have, the following varieties of nephritis:

Right and left chronic interstitial	7
Left chronic interstitial, right kidney normal	4
Right and left chronic diffuse	24
Left chronic diffuse, right kidney normal	1
Left chronic diffuse, right chronic interstitial	3
Right and left chronic parenchymatous	8
Right chronic interstitial, left kidney not operated on	6

The first of the 53 was operated on 14 years and 10 months ago; and the last, 1 year and 3 months ago. The average length of time since operation is a little over five years for each.

The histories of these 53 patients have been followed in all but three instances since the time of operation. In the three cases alluded to the final result is unknown. The life history of each of the remaining 50 has been obtained and recorded, and the final results to date of the 53 patients may be stated in a general way as follows:

Final result unknown	3
Unimproved, or but little improved	6
Improved	11
Cured	33

Before proceeding to an analysis of this list, it is but fair to state that the results are in reality a little better than indicated by the above figures. Thus, of 2 patients who died after operations performed by other surgeons one year and eight years respectively, following renal decapsulation, there is reason to believe that one was cured, while the other was certainly improved. Both of these patients now figure in the list of later deaths, instead of appearing among the survivors. There is also very little doubt in my mind that the number of cured patients will in the near future be increased by a few accessions from those now classed as improved.

Of the 6 survivors recorded as unimproved, only 1 has really experienced no amelioration of any kind. The other 5 all experienced improvement in either general health or in the urine, or in both. All of the 5, however, are at present in better health than before the operation. In 2 of the 5 an associated pulmonary tuberculosis precludes all hope of further betterment.

Of the 11 cases classed as improved, both the general health and the condition of the urine show steady and progressive improvement, continuous from the date of operation to the present day; 3 of the 11 appear to be on the eve of restoration to complete health, their general condition being good and their urine almost normal.

Finally, 33 patients have been completely cured of their former chronic nephritis as a result of the operation performed on their kidneys. In every case the urine has become normal at varying periods of time following the operation and, with the exception of four patients whose urine was found normal for the first time within a few months of this report, has remained normal for a period of six months and upward. These patients, with the four exceptions mentioned, have, therefore, fully met the requirements necessary to entitle them to be regarded as cured. These requirments are: "The urine must remain free from albumin and casts, and the daily urea output be normal, or approximately so, for a period of at least six months following the verification of the disappearance of albumin and casts, and the patient must be free from the symptoms of chronic Bright's disease from which he or she formerly suffered."

It should be added that the vast majority of my patients received no further treatment of any kind for their chronic nephritis after operation; they were not even subjected to the usual restrictions of diet. Whatever benefit they received, therefore, must be ascribed solely to the effects of renal decapsulation.

As already stated, the cure of chronic nephritis is only started by renal decapsulation, and the element of time is essential to obtain the full advantages of the operation. In some patients the health of the kidneys was restored in a few months after operation, while in others the same result was reached only after a period of three years.

To prove that cure or improvement of chronic nephritis after renal decapsulation is due to the operation, it must be shown First, that cure or improvement follows operation with practical uniformity; second, that improvement obtained by operation is steadily progressive in the majority of cases; third, that a cure once obtained is, as a rule, lasting. The first of these conditions has been fulfilled in 81 of the 102 patients; the second in an equal number, 48 of the number progressing steadily up to a certain point, varying with each case, but falling short of complete cure. That some of the 48 will eventually reach complete health I am very confident. This confidence is based on further experience and developments in connection with the "survivors" of my report of 1904. Of the 53 survivors in this report, the 17 who were classed in 1904 as cured are all alive and perfectly well at the present day; while of the 20 patients who were classed as improved, 4 have attained perfect health and now appear in the list of cures.

The third condition, that a cure once obtained must, as a rule, be lasting, has thus far been fulfilled to the extent to be detailed later on by every one of the 33 patients.

Fifteen of the women on the cured list were married at the time of operation; 4 have married since operation; 2 women have given birth to one child each since operation; a third woman has gone through two pregnancies, giving birth to three children. The five children are alive and well. The mothers suffered no kidney disturbance of any kind during pregnancy or since, and are to-day in the enjoyment of perfect health.

SUMMARY OF DATA RELATING TO CURED PATIENTS.

These number 33—4 men, 28 women and 1 female child. The youngest cured patient was 4½ years old at the time of operation; the oldest, 67 years. The average age of the cured at the time of operation was 33 years. Five years, on an average, having elapsed since operation, the present average age of the cured is 38 years.

The average duration of chronic nephritis before operation was 2 years and 8 months for each of the 33 patients; comparison with the average duration before operation of 4 years for the total number of 102 patients; 4 years 11.6 months for the 10 patients who died within two weeks following operation; 4 years 7.3 months for the 39 later deaths; and 3 years 6.9 months for the 53 survivors, speaks louder than words for early operation.

The varieties of chronic nephritis of which these 33 patients were cured were as follows:

Right and left interstitial	5
Right interstitial, left kidney not operated on	4
Left interstitial, right kidney normal	4
Right and left diffuse	11
Left diffuse, right kidney normal	1
Right and left parenchymatous	6
Right interstitial, left diffuse	2

In 13 cases, therefore, the chronic nephritis was interstitial; in 12 diffuse; in 6 parenchymatous, and in 2 interstitial on the right side and diffuse on the left.

The shortest time between operation and cure was one month; the longest, 3 years; 18 patients recovered full health in less than a year after operation; 10 required between 1 and 2 years; 4 did not attain full health until between 2 and 3 years after operation; and in one case fully 3 years elapsed between operation and cure. The average time after operation at which full health of the kidneys was reached was 11 months for each of the 33 patients.

Deducting 11 months, the average time after operation at which the urine became normal, from 5 years, the average time since operation, gives an average period of health of 4 years and 1 month thus far gained for each of the 33 patients.

In the 33 cured patients, the average duration of chronic nephritis was 1 year and 10 months for each of the 13 interstitial cases; 3 years and 5 months for the 12 diffuse cases; 1 year and 1 month for the 6 parenchymatous cases; and 2 years for the 2 right interstitial and left diffuse cases.

The average length of time after operation at which the urine became normal was 6 months for the insterstitial cases; 1 year and 2 months for the parenchymatous cases; and 8 months for the right interstitial and left diffuse cases.

SUMMARY OF RESULTS AND REMARKS.

The results obtained in my first 102 decapsulations of the kidneys for chronic Bright's disease have been detailed fully, frankly and without reservation.

In the first place, renal decapsulation for chronic Bright's disease may be charged with 10 deaths following the operation. Let us admit for the sake of argument that these 10 deaths were all due to operation—a matter by no means settled, as practically every one of the 10 patients was within a few weeks, if not days, of the natural termination of life by disease. These 10 deaths as a result of operation are fully offset by an equal or larger number of patients snatched from impending death by operation. At least 12 others of my patients, who were considered at death's door when I operated, have had months and years added to their lives by the operation, and a number of the 12 are alive and well to-day. The sum total of life added as a result of operation in these 12 cases very far exceeds the curtailment of life which the operation may have caused in the 10 patients who died soon after, as a result of operation. The added years of life, in addition, were for the greater part years of comparative health, comfort and usefulness, as compared with the days or weeks of suffering which, had operation not been performed,

would have been the lot of the 10 unfortunates who died.

To put it another way: Of 22 sufferers from chronic nephritis who came to me for operation, and whose deaths were immediately imminent by virtue of the disease, 12 were saved by operation, while in 10 the attempt to save life failed.

Of the 39 remote deaths none were due to operation. Twenty-nine of the 39 patients ultimately died of chronic nephritis or its complications. Of these only 11 received no appreciable benefit from operation. The worst that can be charged against operation in these 11 cases is that the operation did no good; it certainly did no harm. Eighteen of the 29, as well as the 10 patients who finally died of causes other than chronic nephritis, were all more or less benefited by the operation, the duration of improvement experienced by these 28 patients amounting to a total of more than 33 years.

Of the surviving patients, even the 6 classed by me as unimproved have experienced such marked benefit in general health that, personally, each of the 6 is abundantly satisfied with the results of operation.

Next, of the 11 patients who have all experienced decided improvement in general health and in the condition of the urine as the result of operation, a number appear to be on the high road to complete health, and bid fair later on to augment the list of cures.

Finally we reach the 33 cures of chronic Bright's disease attained as a result of operation. These 33 cures alone would justify all the work that has been done, even if no benefit had accrued to the remainder of my patients. The justification, in my opinion, will still hold good, even if some of the cases now classed as cured should relapse, or in the future become the victims of a new nephritis.

Of the entire 102 patients, therefore, 21 received no benefit from operation, while 81 patients experienced amelioration varying all the way from slight and tem-

porary improvement to complete cure. In 12 cases the operation proved directly life-saving by rescuing the patient from impending death.

In judging the above results, the fact should be borne in mind that the immense majority of my patients came for operation only after all other measures and treatment had failed to arrest the progress of their chronic nephritis. A great number were on the very eve of dissolution, and the desperate character of my series of 102 cases will probably not be duplicated by any surgeon in the future. Better results than those recorded here will undoubtedly be obtained as soon as sufferers from chronic nephritis seek relief and cure in early operation.

In the meanwhile, these results, 33 cures among 99 patients whose ultimate fate is known—obtained in a hitherto incurable malady, and one which, according to the United States census of 1900, ranks sixth in the list of diseases causing death, not alone justifiy the surgical treatment of chronic Bright's disease, but establish that treatment as at present the main if not the only hope of a very large class of sufferers.

For the present, in view of the helplessness of medicine in the presence of established chronic Bright's disease, the advance in treatment represented by renal decapsulation should be welcomed by every physician called upon to treat chronic nephritis. Nor is the physician justified in taking the position that only after all other measures have failed will he resort to decapsulation. That is giving neither the operation nor his patient a fair chance, to which the latter at least is certainly entitled. For even at present I am able to affirm, as the result of experience, that renal decapsulation applied early in the course of a chronic nephritis, and in the absence of complications, is almost free from danger in expert hands, and is almost a certain cure.

That physicians are not unwilling on occasion to try in their own persons methods of treatment which

promise more than those heretofore known to medical science, seems indicated by the fact that of my 102 patients no less than 14 were physicians, and 5 others were members of the immediate families of physicians. One physician and his wife were both operated on during the same afternoon.

Much of what has been said in this paper rests upon the assumption that the curability of chronic Bright's disease by decapsulation of the kidneys is a proved fact. Regarding it as such, I feel that my expectation and hopes of years ago have been in large measure realized, and that the promise of a yet fuller realization appears bright.

12 West Fiftieth Street.

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PROCEEDINGS OF THE SESSION

TUESDAY, JUNE 2—AFTERNOON.

The Section was called to order by the Chairman, Dr. Rudolph Matas, at 2 p. m., in Orchestra Hall.

The recommendations made by the Executive Committee with reference to changing the name of the Section to Section on Surgery, and electing three Vice-Chairmen, were referred back to the committee.

The Chairman, Dr. Matas, made introductory remarks.

A paper entitled "Results of Transplantation of Blood Vessels and Organs," was read by Dr. Alexis Carrel, New York.

Dr. C. C. Guthrie, St. Louis, presented a paper on "Physiologic Aspects of Blood-Vessel Surgery."

Dr. Rudolph Matas, New Orleans, read a paper entitled, "Recent Contributions on the Surgical Treatment of Aneurism by the Intrasaccular Method (Endoaneurismorraphy)—A Statistical Summary."

A paper on "A Successful Ligation of the Innominate Artery, with Presentation of Patient," was read by Dr. William Britt Burns, Memphis, Tenn.

These four papers were discussed by Drs. J. E. Sweet, Philadelphia; J. F. Binnie, Kansas City, Mo.; D. D. Lewis, Chicago; J. A. Dana, New Orleans; D. W. Steiner, Lima, Ohio; George W. Crile, Cleveland; Alexis Carrel, New York; C. C. Guthrie, St. Louis; W. B. Burns, Memphis, Tenn.; and Rudolph Matas, New Orleans.

Dr. James E. Moore, Minneapolis, read a paper on "Local Applications in Surgery." Discussed by Drs. H. A. Royster, Raleigh, N. C.; C. A. Howell, Columbus, Ohio; A. J. Ochsner, Chicago; T. J. Conley, Chicago; J. B. Murphy, Chicago; Robert F. Weir, New York; A. D. Bevan, Chicago; J. N. Jackson, Kansas City, Mo.; Connelly, Minnesota; Charles Parker, Chicago; and James E. Moore, Minneapolis.

A paper on "Bier's Hyperemia" was read by Dr. John F. Binnie, Kansas City, Mo. Discussed by Drs. M. G. Seelig, St. Louis; V. J. Baccus, Chicago; Allison, Indianapolis; D. N. Eisendrath, Chicago; J. B. Murphy, Chicago, and J. F. Binnie.

WEDNESDAY, JUNE 3.—MORNING.

The Section was called to order at 9 a. m.

A joint meeting was held with the Section on Laryngology and Otology.

Drs. Harvey Cushing, Baltimore; C. H. Frazier, Philadelphia, and Frank Hartley, New York, gave lantern slide demonstrations on "Cranial Technic."

Two papers on "Intracranial Complications of Ear and Nose Diseases," were presented by Drs. James F. McKernon and C. G. Coakley, New York.

These five papers were discussed by Drs. J. B. Murphy, Chicago; Albert Jansen, Berlin; V. J. Baccus, Chicago; Willy Meyer, New York; Robert F. Weir, New York; Harvey Cushing, Baltimore; Frank Hartley, New York; C. H. Frazier, Philadelphia; James F. McKernon, New York; and C. G. Coakley, New York.

A paper entitled "The Thyroid and the Parathyroid" was read by Dr. Herman Tuholske, St. Louis. Discussed by Drs. C. H. Mayo, Rochester, Minn.; and A. J. Ochsner, Chicago.

By special permission, Dr. Samuel Lloyd, New York, read a communication from Dr. George M. Edebohls, New York, on "Renal Decapsulation."

Wednesday, June 3.—Afternoon.

The Section was called to order at 2 p. m.

Dr. George W. Crile, Cleveland, delivered the Oration on Surgery, "The Cancer Problem."

A paper on "The Diagnosis at Operation Between Chronic Ulcer and Cancer of the Stomach," was read by Dr. F. B. Lund, Boston.

Dr. William J. Mayo, Rochester, Minn., read a paper on "Ulcer of Duodenum."

These two papers were discussed by Drs. Alexander H. Ferguson, Chicago; Van Buren Knott, Sioux City, Iowa; Parker Syms, New York; W. B. Leggett, New York; F. B. Lund, Boston; and W. J. Mayo, Rochester, Minn.

A paper on "Surgical Diseases of the Pancreas," was read by Dr. John B. Deaver, Philadelphia.

Dr. W. D. Haggard, Nashville, Tenn., read a paper on "Pancreatitis in Its Relation to Gallstone Disease."

These two papers were discussed by Drs. Arthur D. Bevan, Chicago; Carl Beck, Chicago; W. L. Rodman, Philadelphia; William H. Wathen, Louisville; John B. Deaver, Philadelphia; and W. D. Haggard, Nashville, Tenn.

A paper entitled "Is Death in High Intestinal Obstruction Due to Absorption of Autotoxic Glandular Secretions?" was read by Dr. J. W. D. Maury, New York.

Dr. Miles F. Porter, Fort Wayne, Ind., presented a paper entitled, "A Case of Chronic Peritonitis with Complete Obstruction Caused by Numerous Transverse Constrictions of a Previously Undescribed Character Throughout the Intestine."

These two papers were discussed by Drs. William H. Welch, Baltimore; Floyd McRae, Atlanta, Ga.; Clifford U. Collins, Peoria, Ill.; and G. W. McCaskey, Fort Wayne, Ind.

THURSDAY, JUNE 4.—MORNING.

The Section was called to order at 9:30 a. m.

A paper on "Artificial Respiration in Its Physiologic Aspects" was read by Prof. Edward A. Schäfer, Edinburgh, Scotland.

A paper entitled, "Present Status of Surgery of Thoracic Cavity and the Significance of the Author's Method of Preventing Pneumothorax," was presented by Prof. F. Sauerbruch, Marburg, Germany.

Drs. Samuel Robinson, Boston, and N. W. Green, New York, each presented a paper entitled, "Artificial Intrapulmonary Positive Pressure: Experimental Application in Surgery of the Lung."

These four papers were discussed by Drs. H. H. Janeway, New York; Willy Meyer, New York; George E. Fell, Buffalo; John Smyth, New Orleans; J. B. Murphy, Chicago; V. J. Baccus, Chicago; M. B. Tinker, Ithaca, N. Y.; Prof. Edward A. Schäfer; Prof. F. Sauerbruch, Marburg; Drs. Samuel Robinson, Boston; and N. W. Green, New York.

A paper on "Surgical Importance of Cervical Ribs," was read by Dr. John B. Roberts, Philadelphia. Discussed by Dr. J. Clark Stewart, Minneapolis.

THURSDAY, JUNE 4.—AFTERNOON.

The Section was called to order at 2 p. m.

The report of the Anesthesia Commission was presented by Dr. J. G. Mumford, Boston.

Dr. J. L. Yates, Milwaukee, read a paper on "The Effects of Normal and Abnormal Variations in Peristalsis on Peritoneal Absorption." Discussed by Drs. E. Wyllys Andrews, Chicago; A. J. Ochsner, Chicago; and J. L. Yates, Milwaukee.

A paper entitled, "Intestinal Anastomosis; Presentation of a New Simple and Aseptic Method," was read by Dr. Frank B. Walker, Detroit, Mich. Discussed by Dr. F. Gregory Connell, Oshkosh, Wis.

Dr. J. E. Summers, Omaha, read a paper on "Invagination of Limited Annular Gangrene of Small Bowel versus Resection." Discussed by Drs. A. MacLaren, St. Paul; and L. L. MacArthur, Chicago.

A paper on "Gas Cysts of Intestine," was read by Dr. J. M. T. Finney, Baltimore. Discussed by Drs. William H. Wathen, Louisville; and J. M. T. Finney, Baltimore.

Dr. George Emerson Brewer, New York, presented a paper entitled, "Acute Diverticulitis of Sigmoid; Patient Operated on Before Rupture Had Taken Place." Discussed by Drs. D. N. Eisendràth, Chiago; P. E. Truesdale, Fall River, Mass.; and L. L. MacArthur, Chicago.

A paper on "Cancer of Rectum: Deductions from 100 Personal Experiences in Extirpation of Rectum and Sigmoid," was read by Dr. James P. Tuttle, New York. Discussed by

Drs. L. L. MacArthur, Chicago; Joseph Bacon, Macomb, Ill.; Evans, Ohio; Hupper, West Virginia; A. B. Cooke, Nashville; and J. P. Tuttle, New York.

The nominating committee presented the following report, which was adopted: Chairman, J. C. Munro, Boston; Vice-Chairman, J. E. Summers, Omaha; Secretary, John F. Binnie, Kansas City; Orator on Surgery, Harvey Cushing, Baltimore.

FRIDAY, JUNE 5.—MORNING.

The Section was called to order at 9 a. m.

A paper entitled, "My Present Position on Appendix Questions," was read by Dr. Robert T. Morris, New York. Discussed by Drs. A. H. Ferguson, Chicago; Christopher Graham, Rochester, Minn.; D. N. Eisendrath, Chicago; Carl Beck, New York; William L. Rodman, Philadelphia; J. H. Stealy, Freeport, Ill.; C. C. Rogers, Chicago; H. J. Burwash, Chicago; H. A. Royster, Raleigh, N. C.; Charles E. Thomson, Scranton, Pa.; A. J. Ochsner, Chicago; J. B. Murphy, Chicago; and R. T. Morris, New York.

A paper on "Vesical and Renal Calculi and Vesical Tumors" was read by Dr. Carl Beck, New York.

Dr. Joseph Ransohoff, Cincinnati, read a paper on "A New and Rapid Method of Perineal Drainage in Suprapubic Cystotomy."

These two papers were discussed by Drs. H. H. Young, Baltimore; Bransford Lewis, St. Louis; J. E. Cannaday, W. Va.; J. Ransohoff, Cincinnati; and Carl Beck, New York.

A paper entitled, "A Study of Anterior Poliomyelitis, with an Analysis of 647 Cases, from the Children's Hospital, Boston," was read by R. W. Lovett, Boston. Discussed by Drs. H. M. Sherman, San Francisco; E. H. Ochsner, Chicago; and R. W. Lovett, Boston.

Dr. V. P. Blair, St. Louis, read a paper on "A Function of the Lesser Trochanter."

A paper entitled, "Preservation of Anatomic Dissections with Permanent Color of Muscles, Organs and Vessels by a New Method," was read by Dr. Edmond Souchon, New Orleans.

These two papers were discussed by Dr. Peter Potter, Butte, Mont.

On motion of Dr. William L. Rodman, the following resolutions were carried:

Resolved, That the thanks of the members of the Section on Surgery and Anatomy be extended to the distinguished Chairman and most efficient Secretary for the attractive program and the most successful meeting in the history of the Association.

Resolved, That the thanks of the Section be extended to the profession of Chicago for the capacious hall and other arrangements for our accommodation and entertainment.

INDEX